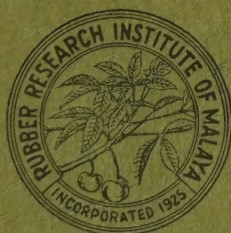


S. P. WILTSHIRE

THE
RUBBER RESEARCH INSTITUTE
OF
MALAYA

ANNUAL REPORT 1939



Published by
The Rubber Research Institute of Malaya
and printed by
Kyle, Palmer & Co., Ltd.

August 1940

Price \$1/-

THE RUBBER RESEARCH INSTITUTE OF MALAYA

MEMBERS OF THE BOARD

31st December 1939

The Director of the Institute
(Mr. H. J. Page, M.B.E.)

Chairman, *ex officio*

The Hon'ble the Financial Secretary,
F.M.S.

Financial Member (appointed by the
High Commissioner under section
5 (i) (b) of the Enactment) (Cap.
108)

The Hon'ble the Director of Agri-
culture, S.S. and Adviser on Agri-
culture, Malay States

Ex officio

CHE HAMZAH M.C.S., BIN ABDULLAH,
The Hon'ble TUAN SHEIKH AHMAD,
J.P., M.S.C., BIN SHEIKH MUSTAPHA

appointed by the High Commissioner
under section 5 (i) (d) of the Enact-
ment (Cap. 108)

Mr. A. P. CRANNA,—*on leave*.
Mr. J. S. FERGUSON, J.P.,—*acting*
Mr. CHOO KIA PENG, C.B.E., J.P.
Mr. D. FARQUHARSON, J.P., M.S.C.
The Hon'ble Mr. B. J. R. BARTON
Mr. W. A. WILKEN, M.C., J.P.

appointed by the High Commissioner
under section 5 (i) (e) of the Enact-
ment (Cap. 108)

The Permanent Committee

The Director of the Institute

Chairman, *ex officio*

The Hon'ble the Financial Secretary,
F.M.S.

Financial Member, *ex officio*

Mr. A. P. CRANNA,—*on leave*
Mr. J. S. FERGUSON, J.P.,—*acting*
Mr. CHOO KIA PENG, C.B.E., J.P.
Mr. W. A. WILKEN, M.C., J.P.

appointed by the High Commissioner
under section 13 (i)(c) of the Enact-
ment (Cap. 108)

CONTENTS

	Page
Report of the Board 	1
Statement of Accounts 	6
Report of the Director 	16
" on the work of the Soils Division 	61
" " " " " " Botanical Division 	83
" " " " " " Pathological Division ...	156
" " " " " " Chemical Division 	196
" " " " " " Experiment Station 	218
" " " " " " Small-holders' Advisory Service	239
" of the London Advisory Committee for Rubber Research (Ceylon & Malaya)	257

Note.—Indexes will be found at the end of each Report (except that of the Board).



Digitized by the Internet Archive
in 2025

REPORT OF THE BOARD

FOR THE

YEAR ENDED 31st DECEMBER, 1939

THE BOARD

The personnel of the Board at the 31st December, 1939, was

- (a) The Director of the Institute (*Chairman*)

Mr. H. J. Page, M.B.E.

- (b) The Acting Financial Secretary, F.M.S. (*Financial Member*)

The Hon'ble Mr. H. R. Joynt, M.C.S., M.F.C.

- (c) The Director of Agriculture, S.S. and Adviser on Agriculture, Malay States

The Hon'ble Mr. W. N. C. Belgrave, M.F.C.

- (d) Members representing the interests of small-holders—

Che Hamzah bin Abdullah, M.C.S., M.S.C.

The Hon'ble Tuan Sheikh Ahmad bin Sheikh Mustapha, J.P., M.F.C.

- (e) Members nominated by Planting Associations—

*Mr. A. P. Cranna—*on leave* (Mr. J. S. Ferguson, J.P. *acting*)

*Mr. Choo Kia Peng, C.B.E., J.P.

The Hon'ble Mr. B. J. R. Barton

Mr. D. Farquharson, J.P.

*Mr. W. A. Wilken, M.C., J.P.

The death of Che Mohamed Noordin bin Jeragan Abdul Shukor, I.S.O. (Orang Kaya Kaya Stia Bijaya di-Raja, Perak) occurred on the 26th June, 1939. Che Noordin was a member of the Board from 15th June, 1934, to the date of his death.

The Hon'ble Tuan Sheikh Ahmad bin Sheikh Mustapha, J.P., M.F.C., was appointed a member of the Board for a period of three years with effect from the 27th June, 1939, in place of the late Che Mohamed Noordin (Gazette Notification no. 3502 of 21.7.39).

*These members served on the Permanent Committee.

Mr. D. Farquharson was on leave for the period 14th April to 13th November inclusive and during his absence Mr. J. S. Ferguson, J.P., was appointed to act on the Board (Gazette Notification no. 2117 of 28.4.39). Mr. Farquharson resumed duty as a member of the Board on the 29th November.

Mr. H. J. Page, Chairman of the Board, returned from leave and resumed his appointment as Director of the Institute on the 12th July. From the beginning of the year until the 11th July Mr. C. E. T. Mann, Head of the Botanical Division of the Institute, acted as Director.

MEETINGS OF THE BOARD AND COMMITTEES

During 1939 the Board held three and the Permanent Committee five meetings; the Estimates (*ad hoc*) Committee held one meeting.

ACCOUNTS FOR THE YEAR 1939

Following this report are the Income and Expenditure account for the year 1939 and the Balance Sheet as at the 31st December, 1939.

The income for the year was—

Contributions from rubber growers, through Administrations	\$645,567 00
Interest on investments and bank balances ...	6,329 86
Sales of rubber and publications, etc. ...	111,284 92
	\$763,181 78

Expenditure was—

Normal	677,844 04
Special:	
Land and Buildings (houses)	7,500 00
Additions to Institute Building	744 94
Furniture for houses	896 00
Furniture for laboratories and offices ...	177 50
Lorry	1,860 00
Experiment Station	20,306 42
	\$709,328 90

From the balance sheet it can be seen that the total excess of assets over liabilities is \$1,392,689.81 represented by

Land and Buildings (Staff houses)	\$267,114 11	
Land and Buildings (Laboratories and offices)	219,508 61	
Land, other than the Experiment Station, for experimental purposes	8,327 28	
Furniture (Staff houses)	17,927 85	
Furniture (Laboratories and offices)	14,797 55	
Plant, Machinery and Apparatus	43,831 88	
Experiment Station	500,084 95	
Stocks	6,681 60	
Sundry Debtors	34,999 25	
Investments	163,012 12	
Cash	207,574 04	
		1,483,859 24
<i>Less</i> Sundry Creditors	\$42,098 80	
Reserve for staff leave pay and passages ...	42,440 49	
Rubber Roadways Committee—balance of grant from the Rubber Experimental Research and Propaganda Fund	6,630 14	91,169 43
		\$1,392,689 81

The realisable investments (at cost) and available cash amount to \$314,416.

SMALL-HOLDERS' ADVISORY SERVICE

At the beginning of 1939 there were 28 Asiatic Rubber Instructors in the Service; during the year one Instructor was transferred to the Laboratory Assistants staff, one vacated his appointment and seven were appointed, making a total of 33 at the 31st December 1939.

The question of the provision of improved planting material for growing rubber by small-holders has been under consideration during the year and in February the Board of the Institute passed a resolution recording its desire "to impress upon Government the desirability of ensuring that sufficient improved material should be available for all small-holders who may wish to plant or replant."

The subject is still being investigated.

ACTIVITIES OF THE INSTITUTE IN 1939 AND 1940

A scheme to enable estates to check the material in nurseries intended for use as budwood was brought into operation and the Institute now sends on request experts to identify the budwood.

Investigations into the life history of the cockchafer grub were continued and in November an Entomologist was appointed to the Institute staff.

Fundamental work on the physiology of latex has been carried on for the past four years at the Imperial College of Science and Technology, London, financed by the Rubber Growers' Association with funds from Malaya. The work is to be continued in Malaya in 1940 by the British Rubber Producers' Research Association in co-operation with the Rubber Research Institute.

Another method of co-operation between rubber research organisations is a proposed meeting in Kuala Lumpur early in 1940 of the Directors of Research from Medan, Buitenzorg, Dartonfield (Ceylon) and Kuala Lumpur to discuss questions of mutual interest.

The war that broke out in September has not seriously affected the work of the Institute but there may be some difficulty in obtaining apparatus and chemicals and the costs of some materials have increased.

H. J. PAGE

Chairman of the Board

H. S. BLACKLIN

Secretary

Kuala Lumpur,

26th February, 1940

ACCOUNTS

INCOME AND EXPENDITURE ACCOUNT

Dr.

EXPENDITURE

	\$	c.	\$	c.
To Experiment Station			119,738	70
„ Board and Committees (Fee and Expenses) ...			1,927	89
„ London Advisory Committee			22,504	35
„ London Secretarial Expenses			11	25
„ Salaries and Allowances			252,982	38
„ Provident Fund			26,599	89
„ Staff Leave Pay and Passages			38,111	00
„ Medical			4,245	65
„ Travelling			26,055	67
„ General Charges (Printing, Stationery, Postage, Telephones, Audit and Legal)			8,721	87
„ Staff Recruiting			89	29
„ Rents, Rates and Insurance			4,202	38
„ General Charges (Laboratories)			1,605	80
„ Maintenance Buildings (Laboratories and Residential Houses)			5,924	02
„ Maintenance Grounds (Laboratories)			1,969	14
„ Laboratories and Offices Cleaning			405	59
„ Furniture and Offices Equipment: Repairs and Renewals			3,753	93
„ Fixtures and Fittings: Repairs and Renewals			1,452	49
„ Plant and Machinery (Repairs and Running)			3,522	95
„ Power, Lighting, Water and Sanitation			11,893	94
„ Motor Vehicles (Running)			2,681	00
„ Workshop			434	31
„ Apparatus and Glassware			6,963	11
„ Chemicals			4,499	60
„ Publications issued by the Institute			14,499	09
„ Library (New Books, Subscriptions to Periodicals and Sundries)			5,192	91
„ Exhibitions and Demonstrations			202	05
„ Small-holders' Advisory Service:				
Film Propaganda	1,370	10		
Asiatic Rubber Instructors	69,068	79		
Experiments on Small-holdings	1,365	27		
Vernacular publications issued	3,769	10	75,573	26
„ Experiments (Field and Testing Laboratory)			31,851	27
„ Depreciation for year			71,834	63
			749,449	41
„ Balance being Excess of Income over Expenditure for the year carried to Balance Sheet			13,503	11

 \$762,952 52

FOR THE YEAR ENDED 31st DECEMBER, 1939

Cr.**INCOME**

			\$	c.	\$	c.
By Contributions from Administrations ...	...				645,567	00
„ Interest on Cash and Investments ...	...				6,329	86
„ Sales of Rubber ...	...	...	105,021	69		
„ Sales of Publications ...	...	...	1,491	31		
„ Rents of Buildings ...	...	...	3,893	66		
„ Miscellaneous ...	...	...	649	00	111,055	66

\$762,952 52

(Sgd.) H. S. BLACKLIN
Secretary

(Sgd.) H. J. PAGE
Chairman of the Board

BALANCE SHEET AS AT

LIABILITIES

		\$	c.	\$	c.
SUNDRY CREDITORS	...			40,668	66
DEPOSITS FOR PUBLICATIONS	...			1,348	26
RESERVES :					
Staff Leave Pay and Passages :					
Headquarters' Staff	...	36,069	18		
Experiment Station Staff	...	6,371	31	42,440	49
SUSPENSE :					
Experiment Station	...			81	88
RUBBER ROADWAYS COMMITTEE	...			6,630	14
EXCESS OF ASSETS OVER LIABILITIES :					
Balance as at 1st January 1939	...	1,379,186	70		
Add Excess of Income over Expenditure	...				
for year	...	13,503	11	1,392,689	81

31st DECEMBER, 1939

ASSETS

	\$	c.	\$	c.	\$	c.
LAND AND BUILDINGS :						
198 (formerly 132) Ampang Road :						
Land as at 1.1.39			10,755	00		
House as at 1.1.39	10,664	49				
Less depreciation for year ...	1,523	49	9,141	00		
200 (formerly 132a) Ampang Road :						
As at 1.1.39	24,241	39				
Less depreciation for year ...	3,463	02	20,778	37	40,674	37
Land behind 198 Ampang Road :						
As at 1.1.39					5,029	35
5 Circular Road :						
Land as at 1.1.39			17,147	08		
Building as at 1.1.39	8,306	61				
Less depreciation for year ...	1,186	66	7,119	95		
3 Houses as at 1.1.39	43,871	97				
Less depreciation for year ...	6,267	42	37,604	55	61,871	58
251 (formerly 163) Ampang Road :						
Land as at 1.1.39			31,440	35		
Building as at 1.1.39	7,713	41				
Less depreciation for year ...	1,101	91	6,611	50		
253, 255, 257, 259 and 261 (formerly 163A/E) Ampang Road :						
Buildings as at 1.1.39	51,708	42				
Less depreciation for year ...	7,386	91	44,321	51	82,373	36
262, 264, 266, 268 and 270 (formerly 184/88) Ampang Road :						
Land as at 1.1.39			27,582	50		
Buildings as at 1.1.39	48,457	61				
Less depreciation for year ...	6,374	66	42,082	95	69,665	45
Land and Building on 4th Mile Ampang Road					7,500	00
Land on Ulu Klang Road					7,705	90
Land on Ampang Road under lease ...			725	98		
Less written off			103	70	622	28
Buildings and Land (Laboratories) :						
Land as at 1.1.39			19,440	00		
Buildings as at 1.1.39	219,892	94				
Add additions during year ...	744	94				
	220,637	88				
Less depreciation for year ...	20,569	27	200,068	61	219,508	61
Carried forward ...					494,950	00

BALANCE SHEET AS AT

LIABILITIES—*(Contd.)*

	\$	c.
Brought forward ...	1,483,859	24

Carried forward ...

1,483,859 24

31st DECEMBER, 1939 (Contd.)

ASSETS—(Contd.)

		\$	c.	\$	c.	\$	c.
Brought forward	...					494,950	00
PLANT AND MACHINERY :							
As at 1.1.39	...			24,330	40		
Less depreciation for year	...			3,649	56	20,680	84
FURNITURE :							
Residential Houses :							
As at 1.1.39	...	19,023	33				
Add additions during year	...	896	50				
		19,919	83				
Less depreciation for year	...	1,991	98	17,927	85		
Offices :							
As at 1.1.39	...	8,314	89				
Add additions during year	...	70	00				
		8,384	89				
Less depreciation for year	...	838	49	7,546	40		
Laboratories :							
As at 1.1.39	...	6,900	82				
Add additions during year	...	107	50				
		7,008	32				
Less depreciation for year	...	700	83	6,307	49		
Library :							
As at 1.1.39	...	1,048	51				
Less depreciation for year	...	104	85	943	66	32,725	40
APPARATUS AND GLASSWARE :							
As at 1.1.39	...			26,057	18		
Less depreciation for year	...			5,211	44	20,845	74
MOTOR LORRIES :							
As at 1.1.39 (old)	...			272	45		
Less depreciation for year	...			92	45		
				180	00		
Add New Lorry at cost	...			1,860	00	2,040	00
WORKSHOP EQUIPMENT :							
As at 1.1.39	...			312	12		
Less depreciation for year	...			46	82	265	30
R.R.I. EXPERIMENT STATION :							
Development expenditure as at 1.1.39	...			490,999	70		
Add additions during year	...			20,306	42		
				511,306	12		
Less depreciation for year	...			11,221	17	500,084	95
LIBRARY BOOKS AND PERIODICALS :							
As at 1.1.39	...			1	00		
Add purchases during year	...			2,359	86		
				2,360	86		
Less written off	...			2,359	86	1	00
Carried forward	...					1,071,593	23

BALANCE SHEET AS AT

LIABILITIES—*(Contd.)*

		\$	c.
Brought forward	...	1,483,859	24

Carried forward	...		
-----------------	-----	--	--

31st DECEMBER, 1939

ASSETS—(Contd.)

				\$	c.	\$	c.	\$	c.
	Brought forward ...							1,071,593	23
STOCKS :									
Petrol and Oil :									
Laboratories ...	...	...	...	607	05				
Experiment Station ...	...	...	...	226	28	833	33		
Empty Drums and Containers :									
Laboratories ...	...	...	...	229	50				
Experiment Station ...	...	...	...	207	00	436	50		
Stationery ...	...	...	...			1,269	59		
Sundry Materials :									
Laboratories ...	...	...	...	498	69				
Experiment Station ...	...	...	...	3,642	49	4,141	18	6,680	60
SUNDY DEPOSITS (For water, Telephone etc.) :									
Laboratories ...	...	...	...			175	00		
Experiment Station ...	...	...	...			20	00	195	00
SUNDY DEBTORS :									
Staff ...	...	...	...			29,079	24		
Accrued Interest ...	...	...	...			650	00		
General ...	...	...	...			3,986	56		
At Experiment Station ...	...	...	...			946	45	34,662	25
SUSPENSE :									
Laboratories ...	...	...	...					52	00
ADVANCE PAYMENTS ...	...	...	...					90	00
INVESTMENTS AT COST :									
4½% Singapore Municipal Loan									
Nominal Value \$15,000/-	...					17,536	69		
3½% British War Loan									
Nominal Value £17,000/-	...					145,475	43	163,012	12
CASH AT BANK AND IN HAND :									
Chartered Bank, London ...	...	...	...			4,963	25		
Chartered Bank, Kuala Lumpur :									
Board's Account ...	...	...	...	171,038	62				
Rubber Roadways Committee ...	...	...	...	6,630	14				
Working Account ...	...	...	...	11,229	33				
Experiment Station ...	...	...	...	13,022	02	201,920	11		
Carried forward ...						206,883	36	1,276,285	20

BALANCE SHEET AS AT**LIABILITIES—(Contd.)**

	\$	c.
Brought forward ...	1,483,859	24

\$1,483,859 24

I hereby certify that to the best of my knowledge and belief all
 Kuala Lumpur,
 14th February, 1940

We have audited the above Balance Sheet and Income and Expenditure
 Malaya, and certify same to be correct according to the best of our information

Kuala Lumpur,
 29th February, 1940

ASSETS—(Contd.)

			\$	c.	\$	c.	\$	c.
Brought forward	...				206,883	36	1,276,285	20
Petty Cash :								
Secretary	...	...	232	70				
Imprest Advances	...	...	70	00				
Experiment Station	...	...	387	98	690	68	207,574	04

(Sgd.) H. J. PAGE
Chairman of the Board

\$1,483,859 24

liabilities to 31st December, 1939, have been brought into account.

(Sgd.) H. S. BLACKLIN
Secretary

Account with the books and vouchers of the Rubber Research Institute of and the explanations given to us and as shown by the books of the Institute.

(Sgd.) GIBSON, ANDERSON, BUTLER & Co.
Chartered Accountants
Auditors

ANNUAL REPORT^{*}

OF

THE DIRECTOR

The Institute was in the executive charge of Mr. C. E. T. Mann, Head of the Botanical Division, as Acting Director, from the beginning of the year until my return from long leave in mid-July, when I resumed direction. I am glad to be able to take this opportunity of expressing my warm appreciation of the able manner in which Mr. Mann discharged these duties during my absence.

The development and conduct of the activities of the Institute continued on the lines set forth in the Annual Reports for 1937 and 1938. The outbreak of hostilities in Europe on September 3rd was followed by a short period of uncertainty about the effect which this might have on the work and staff, but the situation was soon clarified. It was agreed by those responsible for questions of man-power in this country and in Great Britain that the work of the Institute is of such importance that it should not be impeded by curtailment of staff. Members of the staff who were on home leave were therefore afforded facilities to return to Malaya on expiry of their leave, and at the end of the year the Institute had its full complement of staff on duty except for one officer who went on leave in December, one vacancy unfilled, and one new appointment not yet made. The work of the Institute has been little affected by the war. There was a falling-off in requests for technical advice, by about one-sixth; the numbers of incoming letters recorded in our correspondence register for the three four-month periods January-April, May-August, and September-December were respectively 3959, 3877 and 3236. The only technical problems of any importance, arising out of the war, concerned the Chemical Division, and related to the shortage of coagulants (see page 210). Apart from this, work continued in accordance with the normal research programme.

The year 1939 was the first year of the revised International Agreement to Regulate Production and Export of Rubber, under the terms of which new planting on a commercial scale is allowed to the extent of 5 per cent of the planted acreage, and replanting is allowed unconditionally. The year was one of prosperity for the industry. The average price (No. IX Ribbed Smoked Sheet) in Singapore was 31.00 cents per pound, as compared with 24.39 in 1938 and 32.09 in 1937. The exportable percentage of the basic quota was 50 per cent for the first half of the year, and 60 and 75 per cent for the third and fourth quarters (with a domestic

^{*} An index follows page 60.

"cut" of $2\frac{1}{2}$ per cent). The price showed an upward trend, fluctuating between 25 and 30 cents up to the outbreak of war in September, and then varying between 33 and 40 cents for the rest of the year. Planting companies were therefore in a good financial position to engage in schemes of replanting and new planting, and evidently the international situation was not allowed to prevent advantage being taken of the terms of the new agreement, since practically the whole of the over 170,000 acres of new-planting rights were taken up, and over 140,000 acres were actually planted in 1939, whilst the area replanted was over 47,000 acres, nearly double the area replanted in 1938.

The managements of some estates thus found themselves for the first time engaged in extensive schemes of actual planting, as opposed to the management of areas of mature rubber trees in bearing. In preparation for this there was in 1938 a notable increase in the demands which were made on the advisory services of the Institute in connection with the many practical problems of replanting and new planting, and this was maintained in 1939.

It was mentioned in my Report for 1938 (page 17) that it had been agreed to stabilise the income of the Institute, thus freeing it from the fluctuations depending on the vagaries of the export release under the Regulation Agreement. The new arrangement is that the Malayan Rubber Fund will finance the Institute for the five years of the current Rubber Regulation Agreement by paying the excess of expenditure over income from other sources (mostly from sale of rubber from the Experiment Station), in respect of a total expenditure in any one year not exceeding $7\frac{1}{4}$ cents per picul on the Malayan basic quota.

For 1939 this limit represents \$769,781, and the total expenditure (revenue and capital, but excluding depreciation) was well within this figure at \$697,860. The contribution received from the Malayan Rubber Fund was \$643,967.

The Report by Sir Frank Stockdale, K.C.M.G., C.B.E., Agricultural Adviser to the Secretary of State for the Colonies, on his visit to Malaya and neighbouring countries (see Annual Report 1938, p. 38) was published in 1939. Although it deals for the most part with other crops; within the purview of the Department of Agriculture, S.S. & F.M.S., and outside the province of this Institute, many references to rubber growing are also made, some of which are reproduced in other parts of this Annual Report (see pages 24, 25, 36, 38, 40, 42, 43). It is gratifying to be able to quote the following remarks from Sir Frank Stockdale's report:—

"There is no doubt that the rubber industry in Malaya is fully alive to the importance of scientific research and that the Institute is performing work of the highest quality and value for that

industry. It may be said, without fear of contradiction, that the Malayan rubber industry is now being served, as far as technical guidance is concerned, better than any other agricultural industry in the Colonial Empire and I was particularly pleased to note that the emphasis which the Engledow Commission laid on the importance of any policy of applied research being determined by economic considerations is fully recognised by the Board of the Institute, its Director and staff."

STAFF

Three new members of the staff took up their duties during the year. Two of these—the Head of the Chemical Division, and a Soils Chemist,—were to fill vacancies which occurred late in 1938 (A.R. 1938, p. 17). The third was the Entomologist,—a new post, (A.R. 1938, p. 26). Owing to the war, the other vacancy in the Chemical Division was not filled. The appointment of a Publications and Information Officer was again deferred.

The Manager of the Experiment Station left the service of the Institute on 1st June to take up another post (A.R. 1938, p. 18), and the Assistant Manager was appointed Manager in his stead. The Assistant was appointed Assistant Manager. A new Assistant was engaged late in the year, but did not assume duty until 1940.

Seven European officers were on long leave at different times during the year, *viz*, the Director (6½ months); the Head of the Botanical Division (5 months); the Head of the Soils Division (8 months); the senior Botanist (6 months), the Personal Assistant to the Director (½ month), the Pathologist (8 months), the Chemical Engineer (5½ months).

Details of the above staff matters are shown in Appendix II to this report.

The number of Senior staff (Research Officers, Secretary, and European staff at the Experiment Station) at the end of the year was 22.

Because of the heavier incidence of home-leave in 1939, in comparison with 1938, and the failure to fill the vacancy for a Chemist, the effective number of Research Officers on duty in 1939 (14 6/12) was lower than in 1938 (17 5/12).

Five members of the Junior staff left the service of the Institute, and twenty appointments were made (including seven Asiatic Rubber Instructors), four of which were from daily-paid workers already employed by the Institute.

The number of Junior staff at the end of the year, including 33 Asiatic Rubber Instructors, but excluding men on daily rates of pay, was 171.

The Institute also contributed towards the wages of several conductors employed by estates in connection with experiments carried out for the Institute; the wages and expenses of the Asiatic Rubber Demonstrators employed by the Asiatic Rubber Instructors were also paid by the Institute (see p. 242). The number of employees on daily rates of pay, on 31st December, 1939, was 29 at Headquarters (including small-holdings at Ulu Klang and Ampang Road) and 322 at the Experiment Station.

The total number of employees, of all grades, at the end of the year, was thus 544.

The Staff Committee continued to render much assistance, in a consultative capacity, to me and to the Acting Director. It met nine times during the year.

RELATIVE AMOUNTS OF RESEARCH AND ADVISORY WORK

The following table gives the figures for 1939, on the same basis as and in comparison with those for 1937 and 1938 (See Annual Report, 1938, p. 19). On the whole the figures show little variation from year to year. Such variations as there are, which are in the directions to be expected from considerations of staff changes and other circumstances, are dealt with later in this report when the work of the Divisions is dealt with individually.

The values for the three years, for all scientific officers together, are 67, 69, 66 per cent, with an average of 67 per cent, or two-thirds of their time devoted to research and experimental work and 33 per cent to advisory work. In other words, for every two hours spent by the scientific staff on research and experimental work to obtain improved scientific knowledge about the problems of rubber production in Malaya and their solution, one hour is spent in bringing that knowledge to bear on the practical aspects of those problems on Malayan rubber estates.

This may be regarded as a reasonably satisfactory proportion, in view of the magnitude of the industry, and its subdivision into over 2,500 separate plantations of over 100 acres each, and over a quarter of a million small-holdings of less than 100 acres each. Nevertheless, the fact remains that many of the advisory requests which are received relate to questions the answers to which are to be found in the Institute's publications, or in other records and publications. It is often a waste of the time of a specialist scientific officer for him to have to deal with such enquiries when his qualifications could be better used in research work to obtain *new* knowledge for the use of the plantation industry. Reference was made to this aspect of the subject in my Annual Report for 1937 (p. 22). No special arrangements in this regard have yet been possible, but it is hoped to do something about it before long.

Division	Average Number of Scientific Staff			Percentage of time devoted to					
				Research & Experimental Work			Advisory Work		
	1937	1938	1939	1937	1938	1939	1937	1938	1939
Botanical									
All Scientific Officers	5 $\frac{6}{12}$	6 $\frac{10}{12}$	5 $\frac{6}{12}$	80	85	85	20	15	15
Research Officers only	3 $\frac{6}{12}$	4 $\frac{10}{12}$	3 $\frac{6}{12}$	69	78	78	31	22	22
Chemical									
All Scientific Officers	4 $\frac{9}{12}$	5 $\frac{4}{12}$	4 $\frac{3}{12}$	64	74	63	36	26	37
Research Officers only	3 $\frac{9}{12}$	4 $\frac{4}{12}$	3 $\frac{3}{12}$	63	77	66	37	23	34
Pathological									
All Scientific Officers	3	3	2 $\frac{5}{12}$	63	64	72	37	36	28
Research Officers only	2	2	1 $\frac{5}{12}$	47	47	57	53	53	43
Soils									
All Scientific Officers	3 $\frac{3}{12}$	3 $\frac{8}{12}$	3 $\frac{4}{12}$	62	52	57	38	48	43
Research Officers only	2 $\frac{3}{12}$	2 $\frac{8}{12}$	2 $\frac{4}{12}$	50	35	41	50	65	59
Whole Institute									
All Scientific Officers	19 $\frac{6}{12}$	22 $\frac{5}{12}$	19 $\frac{6}{12}$	67	69	66	33	31	34
Research Officers only	14 $\frac{6}{12}$	17 $\frac{5}{12}$	14 $\frac{6}{12}$	57	63	59	43	37	41

Advisory Work—General

EXTENSION WORK

Extension work by the spoken word was confined to lectures; it had been intended to hold another Planters' Conference, but as a result of the outbreak of war no Conference was arranged. Altogether 38 lectures were given, their distribution among the Staff, and among States and Settlements, being shown in the following table (see next page).

The total number of lectures was somewhat less than in 1938, partly because of the smaller number of staff on duty. The distribution among States was still far from proportional to their relative areas of European-owned estates, as shown by the figures

Lectures given by Institute Staff in 1939

State or Settlement	Division					Total	Area of European estates, per lecture (1000s of acres)
	Botanical	Chemical	Pathological	Soils	Experiment Station		
Perak -	4	—	1	1	1	7	37
Selangor -	6	1	1	3	1	12	26
Negri Sembilan -	1	2	1	—	1	5	47
Pahang -	—	—	1	—	1	2	87
Johore -	1	1	—	—	—	2	170
Kedah -	—	1	—	1	1	3	54
Kelantan -	1	—	—	—	1	2	14
Penang & P.W. -	1	—	—	—	1	2	19
Malacca -	—	2	—	1	—	3	27
Total -	14	7	4	6	7	38	43
Rate per Officer	2.5	1.6	1.7	1.8	2.5	2.1	

in the right hand column of the table. However, all Planters' Associations and branches of the Incorporated Society of Planters were given equal opportunities for lectures to be given to them, and inequalities in the relative numbers of lectures actually given are in the main an indication of variations in the demand.

Extension work by the printed word—in the form of the Institute publications,—was further developed. The *R.R.I. Planters' Bulletin*, preparations for which were mentioned in last year's Annual Report (p. 23), commenced publication in February, and eight numbers were issued during the year. The purpose of this new publication can best be stated briefly in the words of the editorial of the first number:—"to give the planter, at frequent intervals, and in concise form, information regarding the *practical* aspects of the scientific work carried out by the R.R.I. and by others; that is to say, the way in which the results of such work may be *used* by him to the benefit of his estate." This new venture was well received (though it was, no doubt, inevitable that its name should be colloquially shortened to "Planters' Bull"!), and there is reason to believe that it really does fill the proverbial "long-felt want."

Another kind of "practical" publication which was introduced during the year was the advisory "Circular." It had long been customary for multigraphed leaflets to be prepared for use in answering enquiries on some of the commoner estate problems. Previously, however, they were sent out only in dealing with such specific enquiries. Many of these leaflets being of general interest, it was decided that all leaflets of which this was true should be printed and sent to all on our mailing list. Ten such Circulars were published during the year *viz*:—

Circular	Title
No. 1	"Manuring Programme for Replanted and Mature Rubber Trees,"
No. 2	"Brown Bast of Rubber Trees"
No. 3	"Insect Pests of Rubber Trees and Cover Plants"
No. 4	"Notes on Bud-grafting"
No. 5	"Notes on Clones"
No. 6	"The Description and Lay-out of Seed Gardens"
No. 7	"Rat Control"
No. 8	"The Use of Serum for Coagulation of Latex"
No. 9	"Coconut Water as a Coagulant for Latex"
No. 10	"Suggestions for the Establishment of Leguminous Creepers under Mature Rubber Trees"

Advisory leaflets in multigraphed form are still used for dealing with enquiries on problems which are of less general interest but yet of not uncommon occurrence.

Another new departure was made, in connection with the Institute's *Journal*. Previously, each volume of the *Journal* has been published in two or three separate Numbers, issued at irregular intervals depending on how long it took to accumulate enough papers to make up a Number of about the usual size. This meant that some papers had to wait some time before publication, and also that the results of the Institute's work were emitted in rather massive batches, rather infrequently. Under the new arrangements, each separate paper is sent to the printer as soon as it has been passed for publication and is then published as a separate "Communication." These Communications are numbered serially, and the pages are numbered consecutively in each year. All those published in the year then constitute that year's Volume of the *Journal* and may be bound together as such. The published results of the scientific work of the Institute's staff are thus made available without needless delay. This new arrangement has been generally welcomed as an improvement on the old system. For 1939 Volume 9 of the *Journal* consists of No. 1, published in July, and containing the following papers:—

- "The Amounts and Distribution of some of the Nutrient Elements in the Rubber Tree".....by A. W. J. Dyck.
- "The Chemical Composition of Rubber Trees in Relation to Problems of Nutrition and Manuring".....by H. J. Page.

- "Plant Hormones".....by E. D. C. Baptist.
 "Palm Oil Diluent for Tar Oil Fungicides, and its effects on Bark
 Renewal in *Hevea*".....by F. Beeley and E. D. C. Baptist.
 "A Nematode Pest of Roots of Cover Plants".....by F. Beeley.
 "Oidium *Heveae* in 1939".....by F. Beeley.
 "The Development of Jungle Reserve Land for Planting with Rubber"
 by H. J. Page.
 "Further notes on Burning, Covers and Manuring".....by C. G. Akhurst.
 "Recommendations for the Choice of Planting Material".....
 by C. E. T. Mann.

together with the following Communications:—

- | | | | | | |
|---------|--------|-------------|----------------------------------|--|--|
| No. 236 | (Aug.) | - | "The Softening of Rubber—Part I" | by V. H. Wentworth | |
| " | 237 | (Aug.) | - | "The Softening of Rubber—Part II" | by J. D. Hastings |
| " | 238 | (Sept.) | - | "Variation in the Composition and Properties of Fresh Latex" | by E. Rhodes |
| " | 239 | (Oct.) | - | "The International Notation for Tapping Systems: Tabulation of Yield Records"* | by E. R. Guest |
| " | 240 | (Oct.) | - | "A Standard International Notation for Systems of Tapping <i>Hevea</i> "* | by E. R. Guest |
| " | 241 | (Dec.) | - | "The Viscosity of Preserved and Concentrated Latex, Part I" | by E. Rhodes and
H. Fairfield Smith |
| " | 242 | (Dec.) | - | "The Viscosity of Preserved and Concentrated Latex, Part II" | by E. Rhodes |
| " | 243 | (Dec.) | - | "The Effect of Variability of Rubber on Vulcanisation" | by J. D. Hastings and
E. Rhodes |
| " | 244 | (Feb. 1940) | - | "Specific Gravity of Latex and of Rubber" | by H. Fairfield Smith |

Planting Manual No. 8, "Budgrafting. Practical instructions for bud-grafting rubber trees," a fully illustrated manual, was published in August as a quadri-lingual edition in English, Malay, Chinese and Tamil, forming Publication No. 2 of the Small Holders' Advisory Service. Separate English-vernacular editions were published in Malay (Jawi) (September), Chinese (October), and Tamil (November), as separate numbers of the corresponding vernacular journals of the Department of Agriculture, S.S. and F.M.S. In each of these the English and vernacular texts are printed on opposite pages. Translations of Circulars Nos. 4 and 5 (see page 22) into these languages were prepared and issued together with the corresponding vernacular editions of the Manual.

* Since revised. (See Communications 246 and 247) (1940).

A Tamil edition of Planting Manual No. 7, of which English, Malay and Chinese editions were published in 1938 (see Annual Report, 1938, p. 23), was published in May, as a separate number of the Tamil Agricultural Journal of the Department of Agriculture, S.S. and F.M.S. The valuable co-operation and assistance of that Department in the preparation and issue of all these vernacular publications is gratefully acknowledged.

The Annual Report for 1938 was published in October, later than usual owing to my absence on leave for the first half of the year.

As in the previous year, articles written by Asiatic Graduate Assistants on the staff of the Institute were published in *Ameasan*, the journal of the All-Malayan Estate Asiatic Staffs' Association; these consisted partly of lectures which had been given at meetings of that Association.

Small Holders' Advisory Service

In pursuance of the policy of gradually enlarging this Service to a cadre of fifty Rubber Instructors, the number of these was increased from 27 to 33. The average area of small holdings per Instructor thus fell to not quite 40,000 acres. However, this figure does not take account of the fact that many Instructors, notably Chinese and Indian Instructors, also give advice to small estates in the 100—500 acres class. Such advice is much in demand now that some new planting, and unconditional replanting, are allowed, and it is evident that special arrangements may need to be made to cater for this demand, so as to prevent too much of the time of the Instructors from being diverted from the small holders, whom it is their primary duty to serve.

The experiment of allowing Instructors to employ Demonstrators who follow up and repeat the work done in the kampongs by the Instructors, has fully justified itself, and twelve such Demonstrators were employed in 1939.

Improvement in the quality of small holders' rubber is still one of the most important aims. In this connection the following remarks of Sir Frank Stockdale in his report, are of interest:—

“Much of the small holders' rubber is still very dirty and if dirt could be eliminated there would be a very large step forward. Additional care and cleanliness is all that is required and it is obvious that the Rubber Research Institute is correct in placing this educational work in the forefront of their efforts on behalf of small holders.”

A set-back to this aspect of the work occurred as a result of the shortage of formic acid because of the war. In spite of the good work done by the Department of Agriculture, S.S. and F.M.S.,

whereby its Agricultural Officers undertook the distribution of available supplies of formic acid to small holders, there was a considerable increase in the use of sulphuric acid, much of it in the form of so-called "locally-made" coagulants sold under fancy names at fancy prices, and consisting of diluted commercial sulphuric acid. At the end of the year administrative steps were contemplated for checking this trade. (See pages 212 and 245).

The problem of helping the small holder to get a better price for his produce, commensurate with improved quality, was referred to in last year's Report (pages 24 and 197). Much useful work was done by the Marketing Officer of the Co-operative Societies Department, who arranged 45 joint sales of small-holders' rubber to exporters, at an average nett profit of about \$1/- per picul (see p. 246). The following extract from Sir Frank Stockdale's report also merits consideration in this regard:—

" . . . a number of improved small smoke-cabinets have been erected. In this connexion I would suggest that . . . attention be also given to the erection of suitable smoke-cabinets by those middlemen who purchase wet sheet from small holders. It is frequently the case that the very small holder requires some cash at short notice, and he obtains this by a day's tapping of his rubber and the sale of his product wet to the nearest dealer. It is unlikely that this system will pass away and the middlemen dealers should be persuaded to provide the necessary equipment for the production of a good quality product. In fact, it might be considered whether such a condition might not be incorporated in his licence."

Considerable interest was taken by small holders in replanting and new planting, and areas of nearly 11,000 and 48,000 acres were replanted and new-planted respectively. This provided welcome opportunities for Instructors further to enlarge the scope of their advice beyond the improvement in the quality of the product, and their work in the wider field was assisted by the confidence of the small holders which had been secured by their efforts in the latter direction. Advice was given regarding soil conservation, covers, manuring, and other features of planting, and in connection with the choice of planting material. In the latter connection, the Institute co-operated closely with the Department of Agriculture, S.S. & F.M.S., in the formulation of plans for making budwood of the best clones, both "free" and proprietary, available to the small holder at prices within his reach.

Fuller particulars regarding these and other aspects of the work of the Small Holders' Advisory Service will be found in the Small Holders' Advisory Officer's report on pages 239 to 256.

Advisory Work (and administration of field experiments)— Estates

Chiefly owing to heavier incidence of home-leave and to a smaller extent to vacancies, the proportion of graduate officers on duty in the four Divisions was lower than in 1938, being 78 per cent ($15\frac{1}{2}$ out of a cadre of 20).

A summary of the advisory and administrative work of the Divisions in 1939 is included in the following table, on the same basis as, and in comparison with, the figures for 1937 and 1938:—

	Division					
	Year	Botan- ical	Chem- ical	Patho- logical	Soils	Total
Visits to Estates (ex- cluding Experiment Station) ...	1939	186	123	80	211	599
	1938	553	99	117	267	1036
	1937	178	121	83	262	644
Interviews at the Insti- tute ...	1939	114	393	85	110	702
	1938	203	368	124	189	884
	1937	174	349	91	145	759
Letters received ...	1939	3166	1356	1251	1604	7377
	1938	2558	889	1444	1577	6468
	1937	1737	927	1508	1330	5502
Letters sent ...	1939	2807	931	1791	1308	6837
	1938	3481	1425	1897	1978	8405
	1937	1949	1162	1435	1763	6309
Specimens and samples received for examin- ation and/or analysis	1939	531	687	399	1628	3245
	1938	377	670	529	2119	3695
	1937	137	595	764	1090	2586
Tours of Visits ...	1939	10	20	5	22	57
	1938	13	21	10	18	62
	1937	11	14	5	23	53
Visits and Interviews and Letters received, per working day per Research Officer ...	1939	3.8	2.2	3.8	3.2	3.2
	1938	3.3	1.1	3.0	2.7	2.2

The distribution of tours of visits was Johore 19, Negri Sembilan and Malacca 11, Selangor and Pahang 4, Perak 13, Province Wellesley and Kedah 13, Kelantan 1. Included in the above are three tours by the Statistician, who made in all 37 estate visits;

these tours and visits are not included in the table. I visited Burma in August to advise the Burma Government in connection with the provision of technical advice to rubber growers, and visited eight estates and a number of small holdings in Burma.

Visits to small holdings are shown separately in the Small Holders' Advisory Officer's report (p. 239).

In comparison with 1938 the table reveals a certain difference in distribution, with fewer visits and interviews, and more letters received. This is no doubt a reflection of the smaller number of staff on duty, necessitating limitation of the number of visits, and dealing with more matters by the often less satisfactory, but more expeditious means of correspondence. It must also be remembered that this Table includes activities in connection with experiments on estates as well as purely advisory work, and that 1938 was an abnormally heavy year for visits, in connection with the Experimental Planting scheme, by the Botanical Division. However, as shown by the figures in the bottom division of the table, the average incidence of the main forms of advisory work and administration of estate experiments, per Research Officer, was heavier than in 1938 for all Divisions.

The total number of letters received at the Institute during the year (exclusive of routine correspondence in connection with publications and library matters) was 11,072, an average of 43 per working day. This includes nearly 3,700 dealt with in the offices of the Director, the Secretary, the Statistician and the Small Holdings Advisory Officer.

An analysis of the advisory correspondence for the three years, 1937, 1938 and 1939, in relation to the territories served, is shown in the following table (see next page).

From the left side of the table it will be seen that the number of estates from which enquiries for advice were received by letter is, for most territories, not widely different from the number of European-owned estates. Taking Malaya as a whole, of the total number of 2509 estates, 996 are European-owned, and 899 estates sent requests for advice. In this analysis of correspondence, it was not possible to distinguish between enquiries from European-owned estates and others, but the above figures indicate that the majority of the European-owned estates do call on the Institute for advice, for although the actual figure is not available, it is known that the proportion of the requests for advice which come from non-European-owned estates is small.

It is noteworthy that, as shown in the right side of the table, the number of estates from which enquiries were received in 1938 shows an increase of 25 per cent (from 560 to 696) over that for 1937, and that the figure remained at practically the same

Distribution of advisory enquiries among States & Settlements

		Estates (of over 100 acres)			Number of Estates from which enquiries were received			
		Total number	European-owned No. per cent		1937-1939 incl.	1937	1938	1939
Perak	-	439	231	53	185	118	144	152
Selangor	-	378	217	57	205	134	162	168
Negri Sembilan	-	334	172	52	124	74	96	87
Pahang	-	166	45	27	47	22	37	35
Total for F.M.S.	-	1,317	665	50	561	348	439	442
Johore	-	542	142	26	151	94	117	121
Kedah	-	245	78	32	79	54	66	64
Perlis	-	6	1	17	—	—	—	—
Kelantan	-	37	21	57	21	9	14	14
Trengganu	-	39	3	8	1	—	1	1
Brunei	-	11	4	36	2	—	2	1
Total for U.M.S.	-	880	249	28	254	157	200	201
Singapore	-	89	17	19	12	5	8	5
Malacca	-	160	44	27	48	35	32	33
Penang & Province Wellesley	-	63	21	33	24	15	17	19
Total for S.S.	-	312	82	26	84	55	57	57
Grand Total	-	2,509	996	40	899	560	696	700

higher level in 1939. Moreover, included in the numbers for 1938 and 1939 are respectively 71 and 52 estates which, according to our records, had never enquired from the Institute before. It is, of course, impossible to say what part of this widening of the range of the Institute's advisory contact with estates is a result of the developments in its activities which have taken place in recent years, and what part is a reflection of the increased prosperity and activity of the industry, notably in connection with new planting and replanting.

The relative smallness of the number of non-European-owned estates which ask us for advice, prompts the suggestion that the

advisory work of the Institute to such estates could with advantage be considerably expanded. However, their relative importance in the Malayan rubber-growing industry cannot be properly judged by the percentage figures in the fourth column of the above table. The majority of the non-European-owned estates are small estates, so that their relative numbers give a false idea of the relative areas involved. The following table shows these areas:—

Areas of European-owned Estates in different States and Settlements

State or Settlement	Area of Estates (of over 100 acres), in 1000 s of acres		Percentage area of European-owned Estates
	Total	European-owned only	
Perak ...	307	255	85
Selangor ...	352	309	88
Negri Sembilan ...	283	237	84
Pahang ...	90	52	58
Total for F.M.S. ...	1,032	854	83
Johore ...	525	340	65
Kedah ...	211	162	77
Perlis ...	2	(0.4)	21
Kelantan ...	33	28	86
Trengganu ...	16	9	56
Brunei ...	6	5	79
Total for U.M.S. ...	793	544	69
Singapore ...	33	15	45
Malacca ...	126	81	64
Penang & Province Wellesley	48	37	77
Total for S.S. ...	207	132	64
Grand Total ...	2,032	1,530	75

For Malaya as a whole, European-owned estates represent three-quarters of the total area planted with rubber on estates.

Nevertheless, the remaining quarter consists of over half a million acres distributed among over fifteen hundred estates

(average size 330 acres), very few of which receive direct advice from us. Many of these are small Chinese- or Indian-owned estates, advice to which would have to be given for the most part in the vernacular. The vernacular editions of Planting Manuals Nos. 7 and 8 (see p. 23) are of special value for such estates.

As mentioned in the report of the Small Holders' Advisory Officer, (p. 242) some of the Chinese and Indian Rubber Instructors in the Institute's Small Holders' Advisory Service give direct advice to small Chinese and Indian estates. But these Instructors are primarily for the service of small holders, and they cannot properly spare much of their time for small Asiatic estates. However, the division between small holdings and estates, at 100 acres, is an arbitrary one, and proposals are under consideration with a view to giving more direct service to the small Asiatic estates in the 100-500 acres class.

The chief subjects about which enquiries were received in notably increased numbers in 1939 are mostly reflections of matters which were receiving increased attention by the Industry or the Institute during the year; *viz*, identification of clones, purchases or exchange of budwood, isolation gardens, planting operations, cover plants,—all indications of the fact that the actual execution of schemes of new planting and replanting was in progress—; tapping; yields of budded rubber in commercial tapping,—in connection with the survey which is being made by the Institute—; latex concentration; coagulation,—as a result of the shortage of formic acid—; crepe rubber; softened rubber.

For most other subjects the numbers of enquiries were not very different from, or were less than, the corresponding numbers for 1938. More detailed information may be obtained by reference to Appendix I of this Report, and to the Reports of the Divisions concerned.

An addition to the service given to estates which has been much appreciated, judging by the use which has been made of it, is the arrangement whereby specially-trained Chinese assistants are available to visit estates and verify the identity of clones in budwood nurseries (p. 153).

Members of the scientific staff were called in to give expert evidence in a court case in which illegal planting of rubber was alleged. As a result of this case, it was evident that care must always be taken, in reports on visits to estates, to distinguish clearly between facts for which the visiting officer can vouch from his own knowledge, and information given to him, in connection with the matter at issue, which he is not in a position to verify.

Research and Experimental Work: General

As in the Report for 1938, the reader is referred to the Report for 1937 (pages 40-45) for an explanation of the principles underlying the structure of the research programme of the Institute, and the scope of work of the Divisions, which still serves as an introduction to those parts of this Report which deal with research and experimental work.

The *Statistics Section* advises regarding the design of all experiments before they are started, and the methods of recording the results; it helps with or itself carries out the analysis of the results, and advises regarding the conclusions which can validly be drawn therefrom. Relevant parts of the Statistician's report are reproduced below.

Design of experiments. The efficiency of modern methods of designing field experiments can be forcibly demonstrated by comparing results now being obtained from experiments laid out in 1938 with those derived from our older experiments. The power of factorial designs, when used with small blocks formed from rationally grouped plots, has been almost spectacular at two estates where soil conditions were exceedingly variable.

"At one estate the error variance per plot was less than half of what it would have been with randomisation within main blocks, ignoring valleys etc.; further, owing to the "hidden" replication of a factorial design, there are virtually 24 replications of each treatment, where otherwise there might have been only about 6; and they are so arranged as to show up an interesting complex of interactions which, without a factorial design, might have been completely overlooked. The standard error of the response in height to a "main-factor" is only 1.3 per cent of the mean height.

"At another estate the confounded-block arrangement has increased accuracy 2.4 times over a freely randomised arrangement. For girth measurements at one year old, the response to nitrogen or to potash, and the mean of each level of phosphate, have been measured with a standard error of 1.3 per cent of the mean; while the standard error of the means of each of 8 qualities of phosphate is 1.8 per cent. Withal the experiment, including boundary belt, covers only 75 acres.

"Unfortunately we still have older experiments with high errors (up to 6 per cent for treatment means in experiments covering 60 acres); some whose estimates of treatment effects may be biased; and some in which, even if differential effects of treatments may be assured, a useful interpretation cannot be conclusively derived because so many factors are "confounded" with the treatments.

The only experimental design of particular novelty produced during the year is that for new clonal-seed families in Field 34 at the Experiment Station. Following J. B. Hutchinson, this has been designed to provide an analysis of variance of genetic constitution within and between families, as well as of the experimental error.

"Analyses of experimental data for progress reports, have been done as follows:—Soils Division—44 experiments; Botanical Division—1 series of correlations; Pathological Division—1 experiment; Chemical Division—1 experiment.

"Sampling investigations: A number of computations have been carried out with a view to evaluating the accuracy which can be retained by various methods of sampling the yield of rubber trees (data from four different experiments). Some tentative reports have been circulated to Divisions. The work is still in progress.

"Experimental technique: In co-operation with the Soils Division some check measurements have been taken on estate experiments with a view to improving methods of recording data.

Existing data have been examined to investigate the error of cup-lump and other methods of recording yields. I have co-operated with Mr. Guest in initiating further experiments on this problem.

The technique of measurement is a subject which has not received anything like the attention which it deserves. Every officer of the research Divisions could usefully devote more study to this matter.

"Special and Miscellaneous Investigations: Data from chemical analyses of rubber leaves from numerous experiments throughout the country have been statistically analysed, and reports sent to Mr. Hamilton. Miscellaneous studies include: correlations of girth with yield and with length of tapping cut; statistical methods of dealing with percentage data derived from small numbers per plot; methods for the statistical analysis of growth curves. These investigations have not yet reached a stage where reports would be justified.

"Papers written for publication are: "Cost of producing rubber relative to size of company" *I.R.J.* 97: 716-7; "Relationship between dry rubber content and viscosity of latex." *J.R.R.I.M.*, Comm. 241: 176-188; Specific gravity of latex and of rubber. *J.R.R.I.M.* Comm. 244: 218-247.

"Estates visited: During the year I visited experiments (or sites for experiments—two visits) on 36 estates (one estate visited twice). These visits included three tours of three or more days.

"Extra-mural advisory work: Visits from, and correspondence with, research workers in five other organisations occupied the equivalent of about three days.

"Machinery: It was decided to hire a Powers-Four Tabulating installation for an experimental period of one year. Unfortunately a tabulator design to my satisfaction was not produced before 1st of September, and owing to mobilisation of the local agent the final plans for the installation had not been produced at the end of the year. Re-organisation of the extensive computational work throughout the Institute was delayed pending acquisition of this machinery. The last two months when research officers have been seeking statistical aid in the preparation of data for annual reports has emphasised the need for improving the present arrangements."

Co-operation with cognate Research Organisations

Close touch was maintained with our sister organisation in Ceylon—the Rubber Research Scheme (R.R.S.)—not only by the regular exchange of reports and correspondence but also by personal visits. Mr. Guest made a short visit there during local leave in February, and I spent several days there on my way back from long leave, in July, when I was able to discuss with the Director, Mr. T. E. H. O'Brien, and his staff, the work in progress, in relation to its co-ordination with the Institute's programme. I was also able to report to Mr. O'Brien and his Board regarding the discussions which had taken place during my leave in England, and the arrangements proposed in connection with co-operation between the Ceylon and Malayan research organisations, their London Advisory Committee, and the newly-formed British Rubber Producers' Research Association (B.R.P.R.A.).

These discussions commenced early in 1939, soon after my arrival in London. Before they took place it was the opinion of the Board of this Institute that the fields of work of the scientific staff of the London Advisory Committee for Rubber Research (Ceylon and Malaya), (L.A.C.), at the Imperial Institute, and of the B.R.P.R.A., were so closely related that the L.A.C. scientific staff and work should be taken over by the B.R.P.R.A. However, in the course of the discussions which I had with the L.A.C. and its staff, and with the Board and staff of the B.R.P.R.A., it soon became evident that circumstances made such fusion both not feasible and undesirable, at least for the time being. On the

other hand, the closest possible co-operation between the B.R.P.R.A., and the L.A.C. staff, and (through the L.A.C.), of the R.R.S. and R.R.I., and the co-ordination of their work, in connexion with all subjects of common interest, was generally agreed to be most desirable. A detailed scheme for such co-operation was worked out, and adopted by the L.A.C. and by the Board of the B.R.P.R.A. In its essentials it provides for the exchange of programmes of work and progress reports, personal contacts between the scientific staffs of these two organisations, and the co-ordination of work on cognate problems. Co-operation scheme. The R.R.S. and R.R.I. co-operate with the B.R.P.R.A. Chairman and one other,—are also respectively a member and Vice-Chairman of the Board of the B.R.P.R.A., and that the Secretaries of both work in consultation to give effect to the scheme. The R.R.S. and R.R.I. co-operate with the B.R.P.R.A. through the L.A.C., and by direct correspondence and visits of their staff when on leave. This scheme was accepted by the Board of the Institute, and by that of the R.R.S. after my return from leave. One of the first concrete results was the transfer of work on the physiology of latex at the Imperial College of Science and Technology, London, formerly financed by the Rubber Growers' Association and since taken over by the B.R.P.R.A., to Malaya for a period of two years. This was agreed to by the Board of the B.R.P.R.A. late in 1939, and the research officer concerned was due to arrive in Malaya early in 1940. A grant for his salary and passage expenses was made by the B.R.P.R.A. and laboratory facilities are provided by the R.R.I.

The B.R.P.R.A. is a part of the International Rubber Research Board (I.R.R.B.), under the International Rubber Regulation Committee, and financed from a special international cess of 1d. per 100 lb. of rubber exported from all territories coming under the International Rubber Restriction Agreement. The other two bodies under the I.R.R.B. are the research departments of the Dutch organisation—the Rubber-Stichting,—at Delft, and of the French organisation,—the Institut Francais du Caoutchouc,—in Paris. Periodical meetings of the Directors of research of these three organisations are (or were) held, and during my leave it was my privilege to attend, by invitation, two such meetings, at Paris and at Amsterdam. The Director of the Proefstation West-Java was on home leave at the same time and also attended these meetings, so that there were welcome opportunities for all-round consultations.

During my leave I was also able to devote much time to visiting the laboratories and staff of the L.A.C. and discussing their work and that of the R.R.I. The Chemical Division of the Institute has always worked in close touch with them, and the



New Clones Experiment: Buddings of Clone R.R.I. 500, 13 months old.



Standard Manuring Experiment: Slicing to cut cover crop roots.
(See Annual Report, 1938, p. 55).

PLATE NO. I.

Experimental Planting: Sub-station at
Photographs taken on



Standard Manuring Experiment: Budded stumps
planted Dec. 1937.



Clone Trial: Buddings of Clone Tj.1, 14 months old.

PLATE NO. II.

Bukit Rajah Estate, Selangor.
5th February 1940.

maintenance of even closer relations in the future is assured by the appointment of one of the L.A.C. scientific staff, Mr. W. S. Davey, to the post of Head of the Chemical Division,—vacant by the transfer of Dr. Rhodes to the B.R.P.R.A. in 1938.

During our home leave the Director of the Proefstation West-Java (P.W.J.) and I were able to agree on preliminary arrangements for a meeting of the Directors of all rubber producers' research organisations in the East, with a view to arranging closer co-operation (See Annual Report, 1938, p. 29). The organisations concerned are the P.W.J., the General Proefstation of the A.V.R.O.S., the R.R.S. and the R.R.I., all of which are financed and controlled locally, and the Rubber Research Department of the P.W.J., which is a branch of, and is financed by the Rubber Stichting. At the close of the year arrangements had been made for the proposed meeting to be held in Kuala Lumpur in February 1940.

Meanwhile, correspondence has continued to be exchanged on technical matters of common interest with the above-mentioned institutions, and with other official stations in Java (Proefstation Mid-Java, Malang; Besoeke Proefstation, East-Java), with the Centrale Vereeniging tot Beheer van Proefstations voor de Overjarige Cultures in Nederlandsch-Indie, Java, as well as with the research organisations of various planting groups in Malaya, Java, Sumatra and Indo-China, as in previous years (See Annual Report, 1937, p. 45).

Mr. Sharp and Mr. Moore visited the Proefstation West-Java in June and May respectively. Mr. Moore also visited the Mid-Java Proefstation at Malang.

Liaison with rubber manufacturing and research interests in the U.S.A. and Great Britain was promoted by visits to the U.S.A. by Mr. Davey on his way to take up his duties in Malaya in April, and by Mr. Piddlesden when proceeding on home leave in September, and by visits to various factories and laboratories in England by Mr. Piddlesden and myself during home leave. During their visits to the U.S.A., Mr. Davey and Mr. Piddlesden attended meetings of the Crude Rubber Committee and the Rubber Division of the American Chemical Society, at Baltimore and at Boston, and visited factories at Akron and elsewhere.

We were pleased to have visits from fellow scientists from many of the institutions mentioned above, and from elsewhere (see p. 59).

Experimental Planting

In the Annual Report for 1936 (p. 38) a statement was given showing the classification of subjects of experiments on estates under this scheme. As stated in the Report for 1938 (p. 29), the

establishment of these experiments, which had to be planted up by the end of the five-years period of the first international rubber restriction agreement (1934-1938 inclusive), was completed by the end of 1938. They consist of 155 experiments on 87 estates, distributed throughout Malaya as shown in the table in last year's Report, and by the map facing this page. A more detailed analysis and classification of these experiments was promised for this report. It has been decided, however, that it would be more convenient and useful to devote a separate publication to this scheme of experiments, which will appear soon after the publication of this report. In referring to this scheme Sir Frank Stockdale remarked in his report "it was very pleasing to see the work which was being done in Malaya by the officers of the Rubber Research Institute in full co-operation with estate managers and agents. Much extra work has been thrown on the staff of the Institute in connection with the experimental plantings, but this has been accepted enthusiastically and the collaboration received from estate interests has been most encouraging." "The results of these trials will without doubt be of great value to the industry in due course and they do mark an excellent piece of co-operative work between the practical planter and a scientific institution." (See Plates I and II, between pages 34 and 35).

The Work of the Divisions

It is customary for me to discuss briefly in my Report the chief problems in the fields of work of the four Divisions and the progress made in the study of these problems during the year. For many readers this is a convenience, but it should be clearly understood that I do not attempt, even in outline, a fully comprehensive review of the work of the Divisions. Anyone requiring this must read the reports of the Divisions. My review must be regarded rather as an annotated table of contents, referring the reader who cannot do this, to those parts of the Divisional reports where some of the more noteworthy findings are recorded.

Soils Problems

The field of work of the Soils Division, and its allocation among the staff of that Division, remain as defined in the Annual Report for 1937 (pages 44, 47-49, and 52), except that Mr. Owen has taken the place of Mr. Hamilton, and that Dr. Dyck has taken over part of the work on leaf analysis and on the chemical composition of the *Hevea* plant, in relation to manuring and nutrition.

The Head of the Soils Division was on home leave for eight months, so that the average effective strength of the Division for the year was 83 per cent of its cadre of graduate officers and 78 per cent of its cadre of Research Officers.

MALAYA

SCALE
0 10 20 30 40 50 Miles

RAILWAY
ROADS
STATE BOUNDARY

CHINA
SEA



STRAITS OF MALACCA

A considerable amount of descriptive and analytical data for soil profiles and parent rock material, was collected, but collation of this in connection with the soil survey had to be deferred (p. 61).

Much further information was obtained from manuring experiments on mature trees and young rubber plants, in the form of records of yield or of growth respectively. Plantations on coastal clay soils and on those derived from the Pahang Volcanic series of rocks continue to show no response to manuring, and such soils must be excluded from the results summarised below. Mature rubber trees have shown definite responses to manuring in both yield and growth from nitrogen manuring and, to a smaller extent, from phosphate manuring. (p. 62). Manuring in April or September seems to be more effective than in December (p. 72). Young rubber trees in new clearings were formerly thought to need no manuring for the first few years, but growth records now indicate clearly a response to phosphate manuring, (p. 64). Young replanted rubber trees are in special need of phosphate manuring, and there is only a small response to nitrogen manuring in the early years (p. 70). Except on light sandy soils known to be lacking therein, potash manuring has had little or no effect on mature rubber trees (p. 63) or on young plants in new clearings (p. 64), and on young replanted rubber trees there is evidence of a depression in growth (p. 71). "Insoluble" phosphates (*e.g.* rock phosphate) seem to be as effective as water-soluble forms (*e.g.* superphosphate), save perhaps for the first application to young plants (page 68). Liming has had an adverse effect on growth in all experiments (p. 67).

Interesting indications have been obtained regarding the relative responses to manuring of plants budded with different clones (p. 69).

The establishment of cover plants under mature rubber trees on non-alluvial soils is a difficult problem the solution of which is still being sought (p. 72). The retarding effect of covers on early growth of young rubber plants is not sufficiently countered by circle-weeding, and strip-weeding is recommended in the early years (p. 72). The benefit to growth to be obtained from mulching has been confirmed, but it appears to be confined to the first year of growth (p. 73). A comparison of different kinds of covers in their effects on growth in new clearings has not so far shown much difference, but the experiments have not yet been carried on long enough to yield conclusive results (p. 73). Digging-in of covers has not yet shown any additional benefit in comparison with mulching (p. 74). The importance of cover

plant problems for Malayan rubber plantations is well stated by Sir Frank Stockdale in his report:—

“It is possible that the importance of covers in old rubber is being overstressed on some estates in Java, particularly when one considers the general high fertility of Java soils, and it is also possible that experimental data is not conclusive as to their immediate value in parts of Sumatra, but the contrast between the general attitude of rubber interests and research workers in the Netherland Indies with those in Malaya in regard to covers under old rubber cannot pass without comment.”

“The conclusion I reached was that much more work on this aspect of rubber cultivation was still required in Malaya, that the long and not the short view should dominate the considerations given to the subject. Measurements of improvements in soil structure and fertility are equally as important as measurements of rubber yields.”

“In the rubber industry, the long view is essential if continuity is to be assured, especially as it is now recognised that replacements of stands at regular intervals of say 25 years by improved planting material may become a normal feature in the system of cultivation. To the observer, the absence of soil covers under mature rubber is one of the marked characteristics in Malaya and under such a system there must be some misgivings as to the future if areas now under rubber are not to be abandoned in favour of opening up new lands . . . Whilst the manuring and inoculation of covers is the subject of current experiments by the Rubber Research Institute I would advocate a greater measure of work in connexion with this problem.”

Out of ten experiments for the comparison of the effects of opening new clearings without burning, with a light burn, or with a “normal” burn, nine have not so far shown any significant difference in growth of the young rubber plants, but in one, unexpectedly, the “no burn” plots show poorer growth at the end of the first year (p. 74).

A useful beginning has been made in work on the preparation of compost (p. 76). Good progress has been made in the study of so-called “phosphate-fixation” in soils. Phosphatic manures applied on the surface seem to be retained in the top inch. According to the kind of soil, from 50 to 95 per cent of the phosphate applied may be rendered not immediately available to the plant, a part of this becoming gradually available later (p. 79).

The problem of erosion and soil conservation is still an important one on Malayan rubber plantations, although the position nowadays is immeasurably better than it used to be in “clean-weeding” days. This subject is dealt with in the Report by Sir

Lewis Fermor on the Mining Industry of Malaya, published in 1939, from which the following passages are extracted:—

“So much blame has been thrown upon the mining industry for damage to rivers and streams due to silt that it seems necessary to emphasise that the mining industry is not the only industry that contributes silt to the rivers in excess of the quantities that Nature would in any case provide. The second culprit in this respect is undoubtedly the rubber industry. . . . Clean-weeding has been a fetish of the rubber industry for many years, and the extent to which estates have been kept free from weeds has been a matter of pride that has found frequent expression in the annual reports of the rubber companies. Malaya is a country of heavy rainfall in almost every month of the year. The result of this clean-weeding has been to expose the soil to direct denudation by this heavy rainfall, causing disastrous soil erosion, of which the exposed roots are the visible witness. From the point of view of the rubber estates, the principal result of this unfortunate policy has been the loss of the most valuable surface soil, the soil that contains the greatest percentage of constituents valuable to the rubber plant; the rubber estates recognising this mistake are now faced with a complete change of policy involving the planting of cover crops to protect the remaining surface soil, helped by expenditure on artificial manuring to rectify as far as possible the mistakes of the past. What interests us now, however, is not the fact of this loss of soil but the destination of the lost soil; for this soil has of course found its way into the streams and rivers of Malaya and must have been a potent contributor with the mining industry to silting of rivers outside the ordinary courses of Nature. There are no retention schemes for impounding coarse silt from rubber estates, allowing only the fines to pass on.”

“The difficulty is to apportion the blame between the two industries. My purpose here is not especially to indict the rubber industry, but to lighten the blame that has been thrown upon the mining industry. It is desirable therefore to attempt to make a crude estimate of the amount of silt contributed by the rubber industry to the rivers. It has seemed to me that the method to adopt would be to take the total acreage in Malaya planted with rubber and to assume an average loss of soil over the whole area, averaging tracts that have probably lost no soil at all, with those that have possibly lost a foot or more of soil, to judge from the exposed root systems. I have discussed this problem with rubber planters met in various parts of Malaya, and the general opinion is that a fair average thickness to adopt would be six inches. When however I put this problem to Mr. Page, the Director of the Rubber Research Institute, and to other officers of the Institute, I found

that they thought that six inches was an over-estimate, but that three inches could be accepted as a certainty." . . . "An average loss of three inches per acre means a loss to Malaya of at least 1,100,000,000 tons since the commencement of the industry, mainly since 1905. That is to say, 33,000,000 tons of silt annually have been contributed to the river systems of Malaya."

. . . "Only five per cent at most of the ground cut in dredging can be sent away, and this in the form of fine slime, the remainder being held up by retention works. Adopting this percentage for all forms of mining, as similar restrictions are applied, the average amount of silt contributed annually to the river systems of Malaya is 16,000,000 tons, mainly slimes that will either find their way in suspension to the sea, or if deposited on agricultural land act in all probability as a fertiliser."

"Rubber, on the other hand, has contributed twice as much silt annually, without any selective retention of coarse material. There is this substantial difference between the two industries, however, that the rubber industry is more widely spread in Malaya than the mining industry. Even then there must be a substantial difference between the extent to which the two industries have produced deleterious effects upon the streams, for whilst the rubber industry adds both coarse and fine material to the streams, the mining industry normally adds fines only."

It would be difficult to gainsay Sir Lewis Fermor's contention—that rubber growers have contributed twice as much soil as tin miners to the rivers and streams of Malaya—but it would be quite wrong to conclude that they are doing so still. However, many of the problems and much of the cost of maintenance of mature (or senile) rubber trees on Malayan estates is a result of the loss of much or all of their top soil in past years, and too much emphasis cannot be laid on the necessity to do everything practicable to conserve the soil in all new planting and replanting. Sir Frank Stockdale also deals with the subject in his report, from which the following is extracted:—

"Erosion has however not been so bad as in Ceylon, probably by reason of the greater regularity and more gentle nature of the rainfall but it is clear that the earlier pioneers in Malaya, as was the case also in Ceylon, did not give as much thought to soil conservation as did those who opened up lands in Java and Sumatra. The position has fortunately now changed and all recognise the importance of soil conservation, even though it must be stated that more can yet be done in practice. In all replantings or in the opening of new areas care is now taken to provide adequate precautions to conserve the soil and its fertility, but in large sections of the older rubber it is clear that more can be done. The provision of lines of stones and bunds along the contours is not

to be compared in extent with the work of a similar character which was done in Ceylon and it is only in the latest plantings that contour terracing along lines similar to those so commonly seen in parts of Java have been adopted. Contour drains have been provided and silt pitting has been undertaken but further thought should be given as to the additional measures against erosion which would be suited to the conditions of the country. It may be held by some that a condition of soil stability has now been reached in soils carrying old rubber and that erosion is not as serious as was the case when the rubber was young. This may be the case, but it cannot be overlooked that this land will at some future date require to be replanted, and that it is essential to future security that the soils should be improved before the replanting is due to be carried out."

But rubber growers are not the only cultivators responsible for soil erosion. Some of the worst offenders are squatters and other temporary occupiers cultivating hill lands for vegetables and similar crops. Legislation intended to prevent this has recently been enacted in the Colony and in Johore. It is realised that more could be done, and during the year His Excellency the Governor and High Commissioner appointed a Standing Committee on Erosion and Soil Conservation to investigate and report on the problem of soil erosion in Malaya, including representatives of the planting and mining industries; there are also officials representing the various Government departments concerned (Agriculture, Forestry, Drainage and Irrigation, Lands) including the administrative and legal aspects; and myself. The work of the Committee has been hampered by the war, special work leaving members little time to devote to the work of the Committee, but in more settled times it is likely to do much good in promoting effective and well-balanced action by all the interests concerned.

The percentage of time devoted to research and advisory work respectively by the graduate staff of the Soils Division in 1937, 1938 and 1939 are:—

	Research			Advisory		
	1937	1938	1939	1937	1938	1939
Mr. C. G. Akhurst ...	39	41	42	61	59	58
Mr. G. Owen *	(66)	(70)	70	(34)	(30)	30
Dr. A. W. J. Dyck ...	28	8	14	72	92	86
Mr. K. S. Pillai † ...	90	90	90	10	10	10

* The 1937 and 1938 figures are for Mr. R. A. Hamilton, who was replaced by Mr. Owen.

† Approximate figures.

Botanical Problems

The field of work of the Botanical Division, and its allocation among the staff of the Division, remained as in recent years (see Annual Reports 1937, pp. 53-55; and 1938, p. 59), except that temporary adjustments had to be made on account of the absence of the Head of the Division from duty with the Division for the whole of the year, first as Acting Director and then on home leave; and of the senior Botanist for the first half of the year on home leave. As a result of these absences the average effective strength of graduate officers on duty for the year as a whole was 79 per cent, and for Research Officers 70 per cent.

The development of improved planting material continues to be one of the most important parts of the work of the Division, and with the extension of replanting and new planting its importance will increase. In this connexion Sir Frank Stockdale's remarks, as in the following extract from his report, merit serious consideration:—

"The percentage of acreage replanted or planned for replanting in Malaya is considerably less than is the case in the Netherlands East Indies and I was informed of no areas in Malaya, which were still yielding satisfactorily, which were being replaced by improved planting material with the object of being prepared for more intense economic competition at some future date. I saw one case in Java, where rubber yielding over 500 lb. per acre was being replaced, because it was anticipated that with improved planting material yields of fully 800 lb. per acre would be secured and that by so doing the competitive position of the estate would be improved should the world price of rubber fall again to low levels. My general conclusion on the information gathered in Malaya was that too conservative a policy was being adopted in regard to replanting and that consideration was being centred perhaps too largely on the prospects of securing releases of new areas for planting."

The statement in the Report for 1938 that clones of higher yielding capacity than the present best proved clones were unlikely to be found by selection from high-yielding estate trees is further supported by the data obtained in 1939, but estates are still being assisted in testing clones derived from such selection work. (p. 130).

It was a disappointing year for hand-pollination work: presumably because of the very dry weather which obtained during the period from flowering to seed fall, the percentage of successful pollinations was low, and so was the proportion of these which resulted in viable seed. (p. 132). Very promising results continue to be shown by some of the seedling families originating

in the crosses made in 1928-31, whilst the "500 Series" of R.R.I. clones derived from these crosses have been further tested and sorted out; a final selection of these clones can soon be made for distribution among estates for trial under a wide range of estate conditions (p. 134 and 137).

The seedling families resulting from the 1937 hand pollinations, and clones derived from them, reached the stage of being established in experiments in the field at the Experiment Station (p. 134). The continuation of the testing of families of illegitimate seedlings of high-yielding clones from plots at the Experiment Station, and from the Tjikado isolated seed gardens, has yielded further interesting results, and some of the families continue to give very high yields (p. 138 and 139).

The present position of the vexed question of the relative commercial merits of buddings and "clonal" seedlings is well summed up in the following extract from Sir Frank Stockdale's report:—

"The results from budgraftings from proved clones show beyond the possibility of doubt that yields greatly in excess of those obtainable from unselected seedling material are being secured in estate practice and that the anticipated difficulties in regard to bark renewal, continuance of yielding capacity, general adaptability and disease susceptibility, have not been experienced to any marked extent." . . . "It is obvious that seedling families will require just as long a period for proving as is taken for proving the buddings of a clone."

The collection of yield records from areas of budded rubber in commercial tapping now embraces over 650 separate areas, (p. 99).

The comprehensive new series of tapping experiments which was inaugurated in 1938 was enlarged in 1939. Together with other tapping experiments already in progress at the Experiment Station, it now comprises 48 experiments. The first year's results from 15 new experiments are included in this Report, together with further results from experiments started earlier. Many of the results reported this year must be interpreted with reserve, for with tapping experiments it is usually necessary to complete at least one bark cycle before the results can be regarded as reasonably related to practice. However, with this reservation, there are a number of interesting indications, while other results from experiments which have now been in progress for several years may be regarded as reasonably conclusive.

Most of the experiments in which "periodic" tapping systems (*e.g.* the so-called A.B.C. with resting periods for one-third of the tapping cycle) are compared with continuous alternate-daily tapping indicate, for both seedling and budded rubber, at various

yield levels, that the yield is reduced in proportion to the resting period, or at least so nearly so that there is not sufficient advantage to be economic. This is in line with the earlier results of the pioneering Seventh Mile experiment. However, later results may show that over a longer period a greater advantage may accrue as a result of better growth, yield, bark renewal and d.r.c. of latex. So far, the results do not indicate that half-spiral alternate-daily tapping is too severe a system for well grown budded trees. (pages 100, 108, 111, 125). A reduced tapping intensity in a continuous system, such as third-spiral alternate-daily, or half-spiral third-daily, may however show a positive response to the lower intensity (p. 114). Full-spiral fourth-daily tapping continues to give better yields and more economic results than half-spiral alternate-daily tapping with seedlings and with many clones, thus belying the theoretical objections to the former system, but the previously noted variations as between different clones continue to be recorded. Thus, clones Avros 50 and 71, B.D. 5 and 10 and Ct. 88 have shown a pronounced advantage in favour of the full-spiral system, the yield with the last mentioned clone in one experiment being almost doubled in comparison with half-spiral alternate-daily, whereas in another experiment clone Tj. 1 showed little difference in yield between the two systems (pages 102, 109, 112-120). Different clones also show considerable variation in their response to double-cut systems of tapping (p. 121) and to daily periodic systems such as half-spiral daily, resting for alternate months, ("D.A.M."), for which clone Avros 152 and perhaps Avros 256 and Ct. 88 seem to be specially suited, but this system seems liable to result often in a slightly reduced yield and growth-rate (pages 109-119, 125). It is probable that monthly periods of rest and of daily tapping are too long, and that shorter periods (*e.g.* 15 or 20 days) are more suitable but here again it is probable that different periods are suitable for different clones (p. 112). Another direction in which clonal differences occur is in relation to the effect of height of tapping. Whereas the yield of seedling trees declines about $1\frac{1}{2}$ per cent for every inch increase in the height of tapping, budded trees usually show a decrease of only $\frac{1}{4}$ per cent, though in some experiments almost three times this figure has been found (p. 104, 127-129). A slaughter-tapping experiment involving systems up to four times the normal intensity is yielding interesting results (p. 121). A new departure in the technique of tapping experiments is the single-task experiment, which promises to yield results more economically than experiments of the older type (p. 116).

The variety of different tapping systems,—experimental or in commercial use—and differences in the conventions used for

describing them in different rubber-producing countries in the East, have emphasized the need for a standard notation for describing tapping systems. Such a system was proposed by Mr. Guest. This system found general acceptance in the countries concerned and was published during the year. Certain modifications were proposed later, which placed the notation on a final basis; this revised notation is used for specifying the different tapping systems in this year's Report. (p. 100).

In the study of the vegetative propagation of *Hevea*, further results regarding the use of growth-promoting substances have been obtained. No practically satisfactory method of propagation by cuttings, even with the use of such substances, has been found (p. 83). For promoting the rooting of budded stumps, however, these substances had already been found to be of value (Annual Report, 1938, p. 61). Further work has shown that the larger and better developed the budded stocks and the less their roots are pruned, the more readily do the stumps root without any special treatment, and the smaller is the effect of growth-promoting substances. Their chief use seems to be for small stumps, especially if they have been severely pruned, as, for example, when they have to be packed for transport to another estate (p. 84).

The investigation of stock-scion relationships has confirmed that the growth of the scion in the early years may sometimes be, but is not always, a function of the vigour of the stock on to which it was budded, and that the effect may become less obvious in later years of growth (p. 87-93). On the other hand, there is further evidence that the yield obtainable from the stock (on high-budded trees) is a positive function of the yielding power of the scion, but the effect is marked only near the union (p. 93).

Further results from the comparative testing of the yields of trees budded with different proved clones, at the Experiment Station, are in line with those for previous years. Tjirandji 1 is still an outstandingly good clone (p. 96).

In the density-of-planting experiment the highest yields (but not necessarily the most economic) are still being obtained, in the ninth year of growth, from the plots with 222 trees per acre. The denser the stand, the thinner the bark, but even in the densest stand (435 per acre) it is tappable (just over 6 mm) and the renewal is adequate (p. 98).

In the physiological work on the nutrition of *Hevea* the pot-culture experiments have yielded further interesting results, notably in relation to the leaf symptoms characteristics of various deficiencies (p. 141).

The ecological studies on the natural cover plants in Field 27 at the Experiment Station (See Annual Report, 1938, p. 106) are being continued, and interesting observations have been made regarding the changes following the closing of the leaf canopy of the rubber trees with the resultant increase of shade (p. 146).

The germination of *Pueraria javanica* seeds, normally very low, can be considerably increased by suitable treatment (p. 147).

A review of the present position of the experiments under the Experimental Planting Scheme (see p. 35) is given on pages 148—152. The abnormally dry weather in most parts of Malaya in 1939, following similar conditions in 1938, has resulted in much delay in these, as in most field experiments. The budding records show that, despite variations among clones in number of buds obtainable per yard of budwood, and in percentage success of buddings, a figure of ten successes per yard may be taken as a fairly safe allowance for most clones.

The division of the time of the staff of the Botanical Division between research and advisory work in 1937, 1938 and 1939 is shown in the following table:—

	Research			Advisory		
	1937	1938	1939	1937	1938	1939
Mr. C. E. T. Mann -	34	37	—	66	63	—
Mr. C. C. T. Sharp -	71	76	73	29	24	27
Mr. E. R. Guest -	100	98	87	—	2	13
Mr. E. D. C. Baptist -	95	96	94	5	4	6
Mr. N. Wright -	78	69	53	22	31	47
Mr. K. N. Kaimal -	91	97	96	9	3	4
Mr. T. V. Vaidyanathan	100	100	100	—	—	—

As a result of Mr. Mann's absence from the Division, as Acting Director and on leave, other members of the Staff had a somewhat higher proportion of advisory work to do.

Pests and Diseases

The newly-appointed entomologist, Mr. Fitzgerald, took up his duties in mid-November. Mr. Napper was absent on home leave for eight months. For most of the year, therefore, Mr. Beeley, with the assistance of Mr. John, was in sole charge of all aspects of the work of the Pathological Division. The average

effective strength of staff for the year as a whole was therefore only 61 per cent of the cadre of graduate officers, and 49 per cent for Research Officers.

The experiments on the control of root disease in young replanted areas yielded further results in confirmation of those obtained previously (Annual Report, 1938, pages 116-123), and valuable indications of the relative economics of different methods and practical considerations of importance in their use, were recorded (pp. 157-170). Stump-poisoning with sodium arsenite seems to be a most effective method for accelerating the decay of the healthy roots of the old stand and minimising the risk of the spread of infection in the replanted stand, but it is not yet possible to say how it compares in cost with the other methods involving physical removal of healthy root material (p. 162).

There are indications that the digging of the centres of root-disease patches may prove to be unnecessary, but this is still not conclusive, and at least an exploratory digging in these centres is advisable (p. 166).

Root-disease surveys in experimental planting areas are yielding useful information in relation to the problem of root-disease control in new clearings. Although the operations for such control are made much more laborious in areas cleared without burning, the incidence of root-disease among new plantings in such clearings appears to be only about half of that found in areas cleared with a "normal" burn (p. 170).

Because of the abnormally dry weather panel diseases such as Mouldy Rot and stem diseases such as Pink Disease were little in evidence, but "sunscorch" was more prevalent than usual (p. 172). Drought appears also to be the predisposing factor for "bark bursts" which were also reported not infrequently during the year (p. 173).

Hevea leaf mildew (*Oidium Heveae*) occurred only to a minor extent throughout the Peninsula, owing to a rapid and heavy wintering and exceptionally favourable conditions for refoliation. Sulphur-dusting was therefore not extensively used (p. 174).

Interesting results were obtained in tests of the resistance of rubber plants to strong solutions of fungicidal and insecticidal materials (p. 177).

Work on the life history of the cockchafer (*Psilopholis vestita*) was commenced, with the assistance of staff kindly lent by the Department of Agriculture, S.S. & F.M.S. (p. 177) and a number of useful pointers for future work on the control of this grub were obtained. From information collected from estates it would appear that the incidence of the pest is stationary, or even diminishing (p. 179). Many more experiments on the control of the

pest by soil fumigants were carried out, but so far nothing more efficient or less expensive than carbon bisulphide has been found (p. 181).

The "trail-injection" method for the control of termites infesting rubber trees has yielded further promising results. The most effective materials for use by this method are perchloride of mercury and a commercial preparation consisting mainly of white arsenic. White arsenic itself was not quite so effective. There is little to indicate that there is anything to support the claim that the commercial preparation concerned contains or owes its efficacy to any biological factor, or that its high price is reflected in correspondingly higher efficiency. Perchloride of mercury in solution, applied by trail injection, has proved to be just as effective in the trials at the Experiment Station, and it costs only a small fraction of the price of the commercial preparation (p. 183).

Rats and squirrels are liable to be troublesome on newly planted areas cleared without a burn, and much attention has been given to dealing with these pests (p. 187).

Tubes of cultures of nodule bacteria, chiefly the strains associated with *Centrosema pubescens* and *Pueraria javanica* have been distributed to many estates, and further tests were carried out on the relative nitrogen-fixing powers of different strains (p. 189).

Studies of latex bacteriology were carried out, partly in conjunction with the Chemical Division, in relation to latex preservation, to the bacterial flora normally associated with latex as it comes from the tree, and to the natural coagulation of latex. (p. 191).

The proportions of their time devoted to research and advisory work by the staff of the Pathological Division, in 1937, 1938 and 1939, are shown below;—

	Research			Advisory		
	1937	1938	1939	1937	1938	1939
Mr. F. Beeley -	53	58	58	47	42	42
Mr. R. P. N. Napper *	42	36	42	58	64	58
Mr. L. D. E. F. V. Fitzgerald †	—	—	96	—	—	4
Mr. K. P. John -	95	93	88	5	7	12

† For 1 month only.

* For 4 months only.

Chemical and Technological Problems

The vacancy for a chemist remained unfilled during the year; Mr. Piddlesden was away on home-leave for over five months, and the post of Head of the Chemical Division was vacant until

the arrival of Mr. Davey in May. The average effective strength of the Chemical Division for the year as a whole was 72 per cent of the cadre of graduate officers, and 66 per cent for Research Officers.

The scientific staff of the London Advisory Committee for Rubber Research (Ceylon and Malaya) (L.A.C.) work in collaboration with the Chemical Division. The Report of that Committee (p. 257) and of its Technical Sub-Committee (p. 265) should be read in conjunction with the report of the Chemical Division. The nature of the work of the L.A.C. staff is summarised in the L.A.C. report and discussed in more detail in the Technical Sub-Committee's report. In addition to much co-operative work on subjects under investigation here, in which problems arising from or peculiar to transport to, and storage or use in, temperate climates, and testing under manufacturing conditions, can usefully be investigated, the L.A.C. staff is specially concerned with methods of testing latex and dry rubber. These are of great importance in connexion with the study of variability of latex and raw rubber, and with attempts to approach closer to standardisation. Fundamental work on latex, of outstanding importance not only for our knowledge of the physical chemistry of latex as a dispersion of latex globules in serum, but also in its bearings on practical questions of latex testing and stability is also being carried out by the L.A.C. staff (p. 265-270).

In Malaya increasing interest in the production and export of latex, instead of dry rubber, was evident, and much of the work of the Chemical Division was concerned with related problems. De-sludging of latex by a centrifugal clarifying machine and by settling were investigated (p. 197). The use of titanium oxide instead of zinc oxide for the filming of latex drums, to avoid discoloration, gave very good results, (p. 199). Spence's method for latex preservation was not found to be commercially practicable for fresh latex (p. 199). Sodium pentachlorophenate, in conjunction with a small amount of ammonia, enables latex to be preserved satisfactorily with a smaller amount of added preservative than when ammonia is used alone (p. 200).

Concentration of latex by creaming can be carried out satisfactorily using Manucol (a sodium alginate preparation) or Schiza Gum (a seed hemicellulose preparation) instead of Tragon seed gum. Creaming power is a function of the viscosity of the "solution" of the creaming agent. Thus, boiled solutions of Tragon seed gum have a much higher viscosity, and a superior creaming power, to solutions prepared in the cold. Viscosity is, however, far from being the only variable involved, for solutions of different grades of Manucol, of widely differing viscosities, did not have

creaming powers directly proportional thereto, and when their strengths were adjusted to give the same viscosity, their creaming powers differed considerably (p. 201).

With the expiry of the Utermark patent, centrifugal concentration of latex is available without patent restrictions. Performance tests of various makes of centrifugal machines were carried out, and the Institute is now in a position to advise estates regarding the installation of centrifugal concentrating plant and its operation (p. 203).

The preparation of soft rubber by incorporation of softening agents in the latex before coagulation, has been further investigated, and is now in large-scale operation on some estates. The use of a rather high temperature during the *early* stages of drying is of importance (p. 204). Work is in progress on the development of methods for the preparation of rubber of low water-absorption capacity (p. 206).

In connection with technological studies on rubber, and the study of variability, much attention has been given to the study of methods of testing and their standardisation (p. 207). A survey of the variability of the sheet rubber produced on a large number of Malayan estates representative of 22 per cent of the planted area of the country has confirmed previous indications that in general variability is a function of inherent variations in the latex and the tree, and is also associated with differences in environment. The prospects of being able to produce a uniform standard rubber all over the country are therefore remote. But the variability in the quality of the rubber from a given estate throughout the year may be only slight, and there does seem to be some scope for the establishment of standard grades for individual estates or groups of estates (p. 208).

Different tapping systems may differ greatly in relation to the variability of the rubber obtained from trees so tapped, and this aspect needs to be taken into account in assessing the relative merits of tapping systems (p. 209).

The abnormal softness of the rubber derived from buddings of clone P.B. 186 has been confirmed; clones have been established from trees which appear to give an even softer rubber than this, and an area has been budded with them (p. 210).

Reference has already been made to the position which arose as a result of the coagulant shortage in the early months of the war (p. 25). The work on re-use of serum for coagulation, and the study of local sources of coagulants—notably coconut water—is dealt with on pages 210-212, together with the work in conjunction with the Pathological Division (p. 192) on natural coagulation.

The R.R.I. "Tunnel" type of smoke-house has become increasingly popular, and a number have been built on estates. Several improvements have been effected (p. 212).

The relative proportions of their time which were devoted to research and advisory work by the graduate staff of the Chemical Division in 1937, 1938 and 1939 are shown below:—

	Research			Advisory		
	1937	1938	1939	1937	1938	1939
Mr. W. S. Davey † -	(39)	(48)	40	(61)	(52)	60
Mr. J. D. Hastings -	96	95	83	4	5	17
Mr. J. H. Piddlesden -	51	52	54*	49	48	46*
Mr. V. H. Wentworth	—	88	68	—	12	32
Mr. K. C. Sekar -	67	62	56	33	38	44

† Figures for 1937 and 1938 are for Dr. Rhodes. Mr. Davey's figures are for 8 months. * For 7 months.

The absence of Mr. Piddlesden on leave increased the amount of advisory work to be done by other officers, especially Mr. Wentworth.

Experiment Station

The report of the Experiment Station is presented this year in a new form. The improved arrangement should greatly facilitate cross reference from the reports of Divisions where work at the Station is involved. Several new experiments laid down during the year are dealt with in Divisional Reports and in the Experiment Station Report.

The planted area increased by 58 acres to 1185 acres, and the area in tapping by 50 acres to 775 acres.

A new clearing was opened without burning. The total cost for the first year, including planting, was \$64.23 per acre. (p. 220).

Over eleven thousand yards of budwood and eighteen thousand seeds were despatched to estates for experimental purposes.

New lines for labourers, and a new bungalow, were erected;—an extension was made to the road system, and an auxiliary water supply was installed.

The total crop despatched for sale in Kuala Lumpur was 387,500 lb. Owing to a change in the method of recording yields in some experiments, a smaller proportion of cup-lump was produced, and more sheet, with a resulting higher average price (27 cents). The total revenue from the sale of rubber was \$104,513/45.

against a total expenditure of \$119,738/70. With an increased crop in 1940 there is every reason to expect the Station to become self-supporting, and to bear an increasing share of the Headquarters costs.

The number of visitors to the Station (524) showed a slight increase compared with 1938 (510)*, in spite of a falling-off after the outbreak of war. Parties from two I.S.P. Branches and from the Estate Asiatic Staff's Association, visited the Station. Three Europeans and 66 Estate Conductors were given refresher courses.

General

The arrangements during the Exhibition of the Malayan Agricultural Association in August were similar to those for 1938. A total of 429 people visited the Institute during the three days of the Exhibition, including 22 Europeans, 32 Malays, 204 Chinese and 169 Indians.

Exhibits were staged at State or District Agricultural Shows, mostly by our Asiatic Rubber Instructors.

During the year 77 books excluding pamphlets and periodicals were added to the Library.

The visitors' book records 861 visitors in the year (803 in 1938). Together with the 429 visitors during the M.A.H.A. Exhibition and the 524 visitors to the Experiment Station, the total for the year is 1814.

A list of 64 visitors from outside Malaya, in Appendix III, includes members of the staff of kindred scientific institutions in Java, Sumatra, Indo-China, Thailand, New Guinea and Holland, whom we were particularly pleased to welcome.

I continued to serve on various outside committees, (see Annual Report, 1937, p. 62).

Close co-operation and friendly relations were maintained with the Director and Adviser on Agriculture, S.S. & F.M.S. and his staff, and with the Controller of Rubber, Malaya, and his staff, whilst cordial relations have also been maintained with the Rubber Growers' Association, the United Planting Association of Malaya, the Incorporated Society of Planters, and the Malayan Estate Owners' Association.

Once more it is a privilege to thank my staff, one and all, for their constant friendly and loyal co-operation and help.

H. J. PAGE
Director

Kuala Lumpur,
31st July, 1940.

* The number of visitors in 1938 was wrongly stated as 725 in last year's report.

APPENDIX I

ANALYSIS OF CORRESPONDENCE BY DIVISIONS, 1939

Soils Division

Subject					Letters received	Letters despatched
Cultivation—						
General Enquiries	...	...	...	...	8	11
Forestry Methods	...	...	...	...	9	7
Experiments	...	...	...	...	43	53
Cover Crops and Natural Covers—						
General Enquiries	...	...	...	...	58	63
Manuring	...	...	...	...	6	6
Eradication by Weed Killers	...	...	...	...	24	26
Manuring	...	...	...	...	365	406
Soil Conservation and drainage	...	...	...	...	4	4
Catch Crops	...	...	...	...	1	1
Replanting	...	...	...	...	225	311
Fertilisers	...	...	...	...	94	102
Soil Samples	...	...	...	...	72	84
Experimental planting under the Rubber Regulation Scheme						
	...	...	...	...	307	407
New Planting	...	...	...	...	22	32
Apparatus	...	...	...	...	3	5
Leaf analysis	...	...	...	...	24	27
Miscellaneous	...	...	...	...	43	59
Total					1,308	1,604

ANALYSIS OF CORRESPONDENCE, 1939

Botanical Division

	Letters received	Letters despatched
I. Budding		
General; Advice on choice of clones;	412	456
Clone Records	126	153
Identification of clones on estates ...	11	11
Training of Conductors and Pupils from Estates, etc.	6	8
Growth of Budded Trees	49	54
Purchases and Exchanges of Budwood		
Packing and Treatment of Budwood ...	11	9
Special materials	7	7
	622	698
II. Tapping		
Estate Enquiries: General	62	86
Estate Experiments: General	85	121
Estate Enquiries (Tapping of Budded Trees)	76	56
Estate Experiments (Tapping of Budded Trees)	270	174
Test Tapping of Seedlings	1	2
Apparatus and Utensils	6	8
	500	447
III. Selection		
Individual Mother-Trees: Selection on estates	5	4
Latex Vessel and Bark Examinations	4	7
Isolation Gardens	43	38
Seed Germination	3	3
Seeds for Experimental Purposes ...	62	78
Requests for Seeds	3	3
Packing of Seeds	12	11
	132	144
IV. General Planting Enquiries		
Information on Planting operations ...	84	85
Replanting	143	174
New Planting	92	110
Cover Plants	131	135
Thinning	4	6
Pollination	19	22
Non-Hevea rubber-producing plants ...	5	6
	478	538

	Letters received	Letters despatched
V. Special Enquiries in connection with Rubber Assessment	15	4
VI. Planting of Experimental Areas on Estates under the Rubber Regulation Scheme	758	870
VII. Yields of Budded Rubber in Commercial Tapping	217	350
VIII. Apparatus	9	10
IX. Miscellaneous	76	105
Grand Total ...	2,807	3,166

ANALYSIS OF CORRESPONDENCE, 1939

Pathological Division

Subject					No. of Estates	Letters Received	Letters Despatched
Root Diseases	...	...	...	...	155	155	198
Stem and Branch Diseases	...	...	...	...	44	58	58
Leaf Disease (<i>Oidium heveae</i>)	...	...	...	...	67	76	83
Leaf Diseases and Pests (Spider, <i>Helminthosporium</i> , etc.)	...	...	...	...	55	60	62
Fungicides and Insecticides	...	...	...	...	48	57	85
Spraying and Dusting	...	...	...	...	14	18	22
Brown Bast	...	...	...	...	5	8	8
Lightning Damage	...	...	...	...	17	14	17
Replanting	...	...	...	...	11	5	11
Cockchafer Grub	...	...	...	...	118	223	452
Insects on Rubber Trees	...	...	...	...	79	102	125
Insects on Cover Plants	...	...	...	...	52	68	87
Diseases of Cover Plants	...	...	...	...	27	28	33
Termite Treatment	...	...	...	...	22	18	28
Requests for Legume Bacteria Cultures	...	...	...	...	166	294	346
Circulars on Cockchafers	...	...	...	...	72	0	72
Miscellaneous	...	...	...	...	65	67	104
Total						1,251	1,791

ANALYSIS OF CORRESPONDENCE, 1939

Chemical Division

Subject	Letters received	Letters despatched
Latex	39	63
Latex Preservation	61	81
Latex Concentration	86	135
Latex—Instruments for determining d.r.c. ...	76	159
Anti-oxidants of Latex	1	2
Anti-coagulants of Latex	7	7
Coagulation	103	122
Coagulating Tanks and Pans	6	17
Rubber Preparation—General Enquiries ...	32	45
Smoked Sheet	142	171
Air-dried Sheet	3	3
Crepe Rubber	57	94
Sole Crepe	1	1
Raw Rubber Powder	2	3
Water Samples	13	16
Machinery for Rubber Manufacture	19	30
Smoke-houses	99	121
Vulcanisation of Rubber	32	55
Accelerators for Vulcanisation	4	4
New Uses of Rubber	3	4
Softened Rubber	45	69
Rubber Substitutes	1	1
Rubber Paving for Road Surfacing	2	2
Rubber Oil	2	2
Analysis of Rubber Goods	1	1
Examination of Non-Hevea and Synthetic Rubber	2	2
Patents	35	36
Quebrachitol	—	1
Orders for Chemicals, etc.	14	27
Apparatus	13	20
Miscellaneous	16	34
Correspondence with Manager Experiment Station	14	28
Total ...	931	1,356

APPENDIX II
Staff Movements in 1939

Officer	Appointment	Assumed duty	Went on home-leave	Returned to duty	Left the Service
C. G. Akhurst	... Head of Soils Division	—	13 April	16 December	—
W. S. Davey	... Head of Chemical Division	12 May	—	—	—
L. D. E. F. V. Fitzgerald	... Entomologist	17 November	—	—	—
H. W. Foston	... Manager, Experiment Station	—	—	—	31 May
C. E. T. Mann	... Head of Botanical Division	—	29 July	—	—
A. Moore	... Personal Assistant to Director	—	20 December	—	—
R. P. N. Napper	... Pathologist	—	24 March	29 November	—
G. Owen	... Soils Chemist	5 January	—	—	—
H. J. Page	... Director	—	—	12 July	—
J. H. Piddlesden	... Chemical Engineer	—	22 July	—	—
C. C. T. Sharp	... Botanist	—	—	27 June	—

APPENDIX III

Visitors from Outside Malaya during 1939

- A. d' Angremond, A.V.R.O.S. Proefstation, Medan, Sumatra.
 F. D. Ascoli, Dunlop Malayan Estates Ltd., London.
 J. A. Aspegren, A. B. Separator, Sweden.
 S. Austen, Revertex Ltd., London.
 L. G. M. Baas Becking, 's Lands Plantentuin, Buitenzorg, Java.
 J. E. Barrs, Newton Chambers & Co., Ltd., Sheffield.
 C. Barclay, United States Rubber Plantations Ltd., Kisaran, Sumatra.
 Sir John Barlow, Thomas Barlow & Bro., London.
 Van Beuzekan, Resident of Karimun Islands.
 J. N. Blackwell, Lawas (Sarawak) Estates, Beaufort, B.N. Borneo.
 R. Bosanquet, Bidor Rubber Estate Ltd., London, E.C.3.
 J. C. Bryant, Tenom Rubber Estates Ltd., Jesselton, B.N. Borneo.
 A. Calver, Rubber Estates Agency Ltd., London.
 R. S. Chantler, United Patani (Malaya) Rubber Estates Ltd., London E.C.3.
 P. J. S. Cramer, 12 Pyrmontlaan, Wassenaar, Holland.
 J. F. H. Cronshey, United States Rubber Plantations Ltd., Kisaran, Sumatra.
 Manuel Cuadros, Chilean Legation, Tokyo.
 W. Deacon, Powers Accounting Machines, Calcutta.
 Luang Vichien Dhatukarn, Bangkok.
 C. K. van Dillen, A.V.R.O.S. Proefstation, Medan, Sumatra.
 E. M. Duraiswami, 127 Pursewalkan High Road Madras.
 G. B. Foote, Elston Estate, Puwakpitiya, Kelani Valley, Ceylon.
 W. G. Freeman, Royal Empire Society, London.
 D. S. Gardner, Pataling Rubber Estates Ltd., London.
 W. Gemmill, Johannesburg, South Africa.
 E. Glasspoole, Tambira Rubber Estates Ltd., Kwala, Sumatra.
 J. L. Groom, Woodbridge, England.
 L. Hassenkamp, I.G. Farbenindustrie, Frankfurt-a-Main, Germany.
 J. W. Henderson, Harrisons & Crosfield Ltd., Medan, Sumatra.
 T. H. van Honert, Treub Laboratory, 's Lands Plantentuin, Buitenzorg, Java.
 H. Hotelling, Columbia University, New York City.
 R. Houwink, Rubber Stichting, Heerengracht 182, Amsterdam.
 H. W. Ingram, Resident, Mukalla, Aden.
 W. H. de Jong, Proefstation Mid-Java, Malang, Java.
 K. E. H. Kay, Kinarut Estate, Jesselton, British North Borneo.
 H. King, Sandakan, British North Borneo.
 L. M. Thuan Komkris, Agricultural Experiment Station, Haadyai, Thailand.
 S. Kosaka, Poeloe Mandi Estate, P.K. Kisaran, Sumatra.
 Prince M. C. Lakshnakara, Bangkok.
 W. T. Lewis, Firestone Tire and Rubber Co., Akron, Ohio, U.S.A.
 Alan C. McKay, Madras.
 A. McKenzie, Avochie, near Huntly, Aberdeenshire, Scotland.
 L. C. de Mel, Galgoda, Panadura, Ceylon.
 H. van der Meyden, Rubber Cultuur Mij. "Amsterdam," Klein Soengei
 Karang, Sumatra.
 P. Michaux, Société des Plantations Terres Rouges, Saigon.
 George Murray, Director of Agriculture, Rabaul, Territory of New Guinea.
 P. A. Morawetz and party, Bangkok.
 K. M. Muller, Harrisons & Crosfield Ltd., Medan, Sumatra.

- V. Nidaegger, Djapoera Estate, Rengat, Sumatra.
 W. F. Nutt, Broome Rubber Plantations Ltd., London.
 E. T. Painton, London.
 R. W. Pyne, Kapala Island Estate, Kapala Islands, Dutch East Indies.
 I. R. Rau, Secretary, Madras Provincial Co-operative Bank, Madras.
 Rao Bahadur M. Giriappu, Registrar of Co-operative Societies, Madras.
 J. Baylor Roberts, National Geographic Magazine, Washington, D.C., U.S.A.
 John J. Serrell Jr., Sharples Corporation, Philadelphia, U.S.A.
 O. B. Schrieke, A.V.R.O.S. Proefstation, Medan, Sumatra.
 K. R. Subramanian, Devakotta, Ramnad District, India.
 R. Thion de la Chaume, Banque de l' Indochine, Saigon.
 R. L. Thambo and party, 29 Mount Road, Madras, India.
 G. S. Tuxford, Beaufort Estate, Beaufort, B.N. Borneo.
 T. A. Wedderspoon, Scottish Malaya Estates Ltd., Edinburgh.
 J. H. Wilson, Yam Seng Rubber Co., Ltd., Dublin.

ANNUAL REPORT OF THE DIRECTOR

INDEX

	Page
Acting Director	16
Advice contained in publications	19
Advisory enquiries, distribution	28
Advisory service to non-European-owned estates	28
Advisory work, summary	26
Advisory work by Statistician	33
Agricultural Shows	52
<i>Ameasan</i>	24
Area planted at Experiment Station	51
A.V.R.O.S., General Proefstation	35
Botanical Problems:	42
Density-of-planting experiment	45
Improved planting materials	42
Natural cover plants, Ecology	46
Nutrition of <i>Hevea</i> , physiological	45
Propagation of <i>Hevea</i> , vegetative	45
Stock-scion relationship investigations	45
Tapping experiments and systems	43
Yields of budded trees, comparative tests	45
British Rubber Producers' Research Association	33
Buddings versus "clonal" seedlings	43
Chemical Division, Appointment of Head	48
Chemical and Technological Problems:	48
Coagulants	50
Latex, concentration and export	49
Smoke-house, R.R.I. "Tunnel" type	51
Soft rubber preparation	50
Variability of sheet rubber, survey	50
Circulars, advisory	22
Circulars translated	23
Coagulants	50
Cockchafer (<i>Psilopholis vestita</i>), life history	47
Communications of the Journal of the R.R.I.	23
Compost	38
Conservation and erosion of the soil	39
Correspondence by Divisions, analysis	26, 53
Cover plant, effect on growth of young rubber plants	37
Crop harvested at Experiment Station	51
Density-of-planting experiment	45
Design of experiments	31
Diseases	46
Divisions, work of	36

	Page
Ecology of natural cover plants	46
Entomologist appointed	46
Erosion and Soil Conservation:	38
Standing committee	41
Legislation to prevent erosion	40
European-owned estates, summary by States and Settlements ...	29
Experimental data for progress reports, statistical analyses ...	32
Experimental Planting areas:	35
Experimental technique	32
Survey of root diseases	47
Extension work	20
Experiment Station:	51
Area planted	51
Crop harvested	51
Visitors	52
Fermor, Sir Lewis, Report	39
Income stabilised	17
Investigations, special and miscellaneous, by Statistician ...	32
Institut Francais du Caoutchouc	34
International Rubber Research Board	34
Interviews at Institute	26
Journal of the R.R.I., contents of Vol. 9	22
Latex:	
Bacteriology	48
Concentration and export	49
Physiology	34
Leaflets, advisory	22
Lectures	21
Letters received and sent, summary ..	26
London Advisory Committee	33
Malayan Agri-Horticultural Association Exhibition	52
Machinery, Statistical	33
Manuring	37
Natural cover plants, ecology	46
New clearings, methods of opening	38
Nodule bacteria cultures	48
Nutrition of <i>Hevea</i> , physiological	45
Pests and Diseases:	46
Control of root diseases in young replanted areas	47
Cockchafer (<i>Psilopholis vestita</i>), life history	47
Latex bacteriology	48
Nodule bacteria cultures	48
Rat and squirrel damage	48
Survey of root diseases in experimental plantings	47
Termite control	48
Planting materials, unproved	42
Planting Manual No. 8	23
Planters' Bulletin	21

	Page
Planters' Conference	20
Propagation of <i>Hevea</i> , vegetative	45
Proefstation West-Java, Rubber Research Department	35
Rat damage	48
Research and Advisory Work, Relative amounts:	19
By graduate staff of Botanical Division	46
" " " " Chemical Division	51
" " " " Pathological Division	48
" " " " Soils Division	41
Research and experimental work: general	31
Research Institutions, co-operation with:	33
A.V.R.O.S., General Proefstation	35
British Rubber Producers' Research Association	33
Institut Francais du Caoutchouc	34
International Rubber Research Board	34
Java, official stations	35
London Advisory Committee	33
P.W.J., Rubber Research Department	35
Rubber Research Scheme (Ceylon)	33
Rubber Stichting, Delft	34
Rubber Research Scheme (Ceylon)	33
Rubber Stichting, Delft	34
Samples for analysis	26
Sampling investigations, statistical	32
Small-holders' Advisory Service	24
Smoke-house, R.R.I. "Tunnel" type	51
Squirrel damage	48
Specimens for examination	26
Soft rubber preparation	50
Soil Problems:	36
Cover plants	37
New clearings, new methods of opening	38
Manuring	37
Soil erosion and conservation	38
Staff	18
Staff movements	58
Staff Committee	19
Statistician, Report	31
Advisory work	33
Analyses of experimental data for progress reports	32
Experimental technique	32
Investigations, special and miscellaneous	32
Machinery	33
Publications	32
Visits to estates	33
Stockdale, Sir Frank, report:	
Buddings and clonal seedlings	43
Cover-plant problems	38
Experimental planting	36
Improved planting material	42
Sheet preparation by small-holders	25
Soil erosion	40
Work of the R.R.I.	17
Stock-scion relationship investigations	45

					Page
Tapping experiments and systems	...	...	...	...	43
Termite control	...	...	...	...	48
Tours of visits by Research Officers	...	...	...	...	26
Variability of sheet rubber, survey	...	...	...	...	50
Visits to estates, summary	...	...	...	...	26
Visitors to the Experiment Station	...	...	...	...	52
Visitors to the Institute	...	...	...	...	52
Visitors from outside Malaya	...	...	...	...	59

ANNUAL REPORT *

SOILS DIVISION

For the first three months of the year the Senior Staff of the Division was at full strength, Mr. G. Owen having commenced duty on 5th January, 1939. The Head of the Division went on home leave on 13th April, 1939, and returned on 16th December, 1939, a delay of six weeks in his return having occurred owing to war exigencies. During the absence of Mr. C. G. Akhurst the work of the Division was under the joint control of Mr. G. Owen and Dr. A. W. J. Dyck, Soils Chemists.

I. Soil Survey Work

During 1939 the soil profiles which were analysed totalled 141, involving 14,320 determinations on 828 samples, and whilst over one-third of these were examined for advisory purposes they all have a direct or indirect connection with soil survey work in that the analyses are available for comparative purposes. It was not possible to examine and collate the data which are at present available.

When opportunity offered specimens of parent rock material, both weathered and unweathered, were collected and identified, and considerable help in this connection has been obtained from the Director and members of the Geological Survey Department, who have also supplied a set of rock specimens for the Division.

II. Manuring of Hevea

Large-scale field experiments have continued to be the basis of the work of the Soils Division during the year, since field experiments carried out according to approved methods are universally accepted as a satisfactory method of approach, pending the accumulation of data regarding the more fundamental properties of the soils which can be obtained by more extensive and intensive survey of Malayan soils. When applied to perennial crops in the mature stage this method of investigation is admittedly slow, because general physiological response to treatment takes place gradually, but numerous experiments on immature rubber trees are already yielding valuable information upon which a general policy can be based.

* An index follows page 82.

A. MATURE TREES

General observation and examination of results of manuring experiments on mature rubber trees support the conclusion that reaction to treatment is rather similar on most types of inland soils, also depending usually on age and vigour of the rubber trees as much as on soil type. Exceptions are sandy soils (especially those of alluvial origin) and soil derived from rocks generally grouped as the Pahang Volcanic Series.

Alluvial soils of the coastal districts are in a class apart; experiments in progress on the heavy clay soils of the western coast have not yet shown any response to treatment with fertilisers. The alluvial expanse on the east coast is of less economic importance and has not been studied to the same extent in consequence, but it appears that these alluvial soils are more variable and generally less fertile than the coastal clays on the western border of the Peninsula. References made in this report to coastal clays will refer only to the heavy alluvial soils on the western borders of Selangor, Perak and Province Wellesley.

The lack of positive evidence from the manuring experiments on mature rubber trees which are hereinafter mentioned is largely because of the comparatively short length of time the experiments have been in existence; periods of at least 5 to 10 years must be regarded as necessary for conducting manuring trials on mature rubber areas.

Manuring of mature rubber trees on coastal clays

Nine experiments have been in progress since 1936 and in none of these is there any indication so far that manuring is having an effect on either growth or the yielding capacity of the trees. It should be stated that the trees in these areas are very well grown, being typical of rubber trees on this particular soil type, and it is expected that even if an effect does appear it will be difficult to detect in the early years of manuring. In any case there are no indications now that manuring is essential on these soils.

Manuring of mature rubber trees on inland soils

1. Effect of manuring on growth

The beneficial effect of nitrogen on growth is indicated at three experimental centres* (HM, TM and PM), but as the trees are fairly vigorous in these areas, the increase is small. The effect of phosphate is also small but highly significant at two

* A key to the localities of experimental centres is on p. 82.

centres (HM and TM). The soil types on which response to phosphate manuring has been demonstrated are as follows:

- (a) deep friable medium loam derived from granite
- (b) heavy loam derived from shale or phyllites.

There is little or no evidence that potash has had any measurable effect on rubber trees growing on the more important types of inland soils. The probability that it has been slightly beneficial is indicated at only one of the numerous experimental areas (UM). On sandy soils, especially those of alluvial origin, marked response to potash would be expected in the normal course of events and there is no evidence that manuring with mixtures containing potash has ever been ineffective. However, none of the experiments under consideration is situated on sandy soils, and because the requirements of such soils are known the need for experimentation on these types is not urgent.

The effect of potash on old rubber trees requires further investigation, but meanwhile there are indications that in general the effect of its omission is not serious. Its inclusion as an insurance against a possible disturbance of the physiological activity of the trees by lack of "balance" in the manuring may be advisable.

2. Effect of manuring on yield

Little new information of interest in this respect has been obtained during the period under review. Results tend to confirm conclusions regarding the beneficial effect of nitrogen (PM and TM), but there is no evidence that phosphate has had a similar effect on yield in any of the experiments. It is of interest to note that some experiments show negative (although not significant) response to potash (*e.g.* TM and LM).

At the R.R.I. Experiment Station on a light sandy to sandy loam soil (F.6), potash manuring continues to maintain an improved yield.

Regarding the rate of application of fertilisers there are no indications that 3 cwts. per acre are more effective than $1\frac{1}{2}$ cwts. of mineral phosphate per acre (TM, LM and HM).

B. IMMATURE TREES IN NEW CLEARINGS

Experiments on manuring of young immature trees in new clearings have made steady progress and have yielded much useful information. Some experimental areas which made a poor start

owing to a variety of factors such as late planting, rat damage, etc. have since recovered and are generally satisfactory from the experimental point of view. Budding was carried out in the majority of areas during the year under review, only a few remaining to be budded in 1940.

Results from which conclusions are drawn in this report are mainly those obtained before budding, but a few results are available from areas budded before or early in 1939.

It is generally known that the virgin soils of Malaya are not rich in a chemical sense and perhaps it is not surprising to find that phosphate manuring has had a beneficial effect on growth of young rubber plants on nearly all types of inland soils. The degree of response to this treatment varied according to soil type, but in other respects all types of inland soils have behaved rather similarly. (Soil derived from basalt will probably prove to be an exception but no results are available from the one experiment (AK estate) on this soil type).

The results obtained from numerous experiments are sufficiently consistent to justify drawing the following general conclusions:

1. A small increase in the rate of growth can be expected as a result of nitrogen manuring, but this is probably not economically significant.
2. A growth increase following phosphate manuring is more or less assured on virgin inland soils. The beneficial effect may be quite appreciable on many soils and it is safe to say for all virgin inland soils except those of Pahang Volcanic Series, that the use of small quantities of phosphate at the time of, or shortly after, planting is an economically sound practice.
3. Potash has no apparent effect on growth of young rubber on virgin soils. Some results tend to indicate that potash may be harmful during the early stages of growth, but a statistically significant result has been obtained in only one experiment (F estate).

Out of 14 manuring experiments on virgin inland soils, in various parts of the country a significant response to phosphate has been observed in 13, (experiment CH being the exception). Three similar experiments on lalang land have also shown a very marked beneficial effect from phosphate manuring. The results may be summarised as follows:

Growth of Young Rubber Trees on New Clearings—Percentage comparison

Height (or Girth) Before budding	(1) (No Manure)	n	nk	np	pk	npk	p	k	Parent material of soil
Estate A (Johore)	100.0	108.3	112.0	117.9	104.3	112.4	110.9	97.8	Granite
„ B („)	100.0	116.7	117.9	117.5	106.9	133.9	115.3	100.7	„
„ C (Perak) (girth)	100.0	110.8	97.6	108.9	108.6	108.6	102.9	101.0	Inland alluvium
„ D (Johore)	100.0	104.6	110.7	127.8	108.8	136.9	—	—	Granite
„ E (Pahang)	100.0	102.4	104.8	110.3	102.1	108.7	—	—	Shale
„ F (Kedah)	100.0	104.8	104.8	126.3	111.4	113.7	—	—	Quartzite
„ G (Selangor)	100.0	98.8	116.2	112.8	112.8	111.6	—	—	„
„ H (Johore)	100.0	98.7	95.5	119.8	114.4	112.9	—	—	Granite
Average	100	108	107	117	109	117	—	—	
Height or Girth of buddings									
Estate C (Perak)	100.0	109.6	100.5	114.6	108.1	109.0	104.8	103.8	
„ E (Pahang)	100.0	100.2	101.5	109.5	104.8	108.2	—	—	
„ F (Kedah)	100.0	103.5	101.2	107.1	104.4	106.2	—	—	
„ G (Selangor)	100.0	109.1	106.8	125.6	117.9	122.4	—	—	
„ H (Johore)	100.0	101.4	102.6	124.4	124.2	126.9	—	—	
Average	100	103	102	110	107	109	—	—	
Alluvial soils (coastal) Buddings									
Estate K (Perak)	100.0	98.8	84.0	99.5	96.7	97.1	—	—	Heavy clay
„ L (Selangor)	100.0	96.8	95.4	97.5	98.7	98.6	—	—	Peaty loam

It will be observed that manuring has had no effect on growth of rubber trees on alluvial soils; on the contrary, fertilisers appear to have had a slight depressing effect. These experiments are situated on the coastal alluvium on the western border of Perak and Selangor. It is evident that manuring of virgin land in this district is not desirable.

Other manuring experiments

Experiments designed with the object of comparing the effects of different rates of application of N, P and K are in progress and the general effects observed confirm conclusions drawn from the series of experiments mentioned above *i.e.* that phosphate is beneficial on inland soils but manuring is quite ineffective on coastal clays. In addition the results indicate that within limits larger quantities of phosphate produce slightly better results but not proportionately.

Height Increments in six months ($\frac{1}{4}$ -foot units)

	<u>N₀</u>	<u>N₁</u>	<u>N₂</u>	<u>P₀</u>	<u>P₁</u>	<u>P₂</u>	<u>K₀</u>	<u>K₁</u>	<u>K₂</u>	
Estate M (N.S.)	- 14.27	14.26	14.82	11.34	15.83	16.17	14.49	14.59	14.27	
„ N (N.S.)	- 21.52	21.17	19.52	17.65	21.78	22.78	21.24	20.96	20.01	
„ O (Perak)	- 13.24	12.40	13.40	12.69	12.95	13.31	13.79	12.89	12.36	Coastal clay

Phosphate manuring Experiments

Having established that phosphate deficiency is a characteristic of local inland soils and that on such soils the addition of this element has a fairly consistent beneficial effect it remains to consider the optimum quantities required for growth. Six experiments are in progress designed to investigate the problem of phosphate manuring in more detail. Significant response has been observed in four of these experiments. In the remaining two experiments the effect is not proven (statistically) but there are definite indications that phosphate has had a small positive effect.

Too much reliance must not be placed on the averages shown here, since the standard errors of the experiments are variable, and the results of two of them are not statistically significant.

The standard errors of the first three experiments are low so we may safely consider those results in more detail. There are strong indications that the phosphate effect has increased with increasing quantities of this plant nutrient. The unit quantity used at the time of planting on these experiments was $\frac{1}{2}$ oz. superphosphate per point, and the maximum rate of application (p_7) $3\frac{1}{2}$ oz. Taking the mean of the first three experiments (results of which are in each case statistically significant) the percentage increases for the different rates of application of phosphate are as follows:

$\frac{1}{2}$ oz.	$1\frac{1}{2}$ oz.	$2\frac{1}{2}$ oz.	$3\frac{1}{2}$ oz.
4.9	9.3	12.6	16.6

Percentage Comparison of Growth (height)

Seedlings		(1) (No Manure)	p ₁	p ₂	p ₃	p ₇	CaO	p ₂ CaO	np ₅ k
Estate P (N.S.)	-	100.0	109.1	109.7	113.7	116.9	90.3	108.1	118.8
„ R (Johore)	-	100.0	104.0	110.1	115.3	117.2	95.8	110.4	109.8
„ U („)	-	100.0	101.7	108.1	108.9	115.7	97.8	95.0	97.5
„ B („)	-	100.0	105.8	118.5	107.9	111.4	92.1	104.2	95.3
„ T (N.S.)	-	100.0	96.2	89.2	98.8	106.7	87.1	101.8	94.4
„ V (Selangor)	-	100.0	109.0	103.5	102.1	106.0	97.7	97.0	104.9
Buddings									
Estate P (N.S.)	-	100.0	113.3	100.7	117.4	116.6	98.8	109.0	115.7
„ B (Johore)	-	100.0	102.2	106.0	99.5	105.0	92.7	99.5	95.8
Average	-	100	105	106	108	111	94	103	104

Lime has had an adverse effect on growth in all experiments. This is probably due to excess alkalinity of the soil, as a result of the addition of lime 3 lb. per point being used, rather than to the harmful effect of calcium as a nutrient element. The main object of the addition of lime in this series of experiments was to determine the relative effect of phosphates in the presence and absence of lime. This problem is closely connected with the fixation of phosphate by soils and is being more fully investigated. At the present stage there is no evidence to show that a dressing of lime is required for optimum growth of young rubber plants; excess lime is definitely harmful. Further, the results do not show that the effect of phosphate is enhanced in the presence of lime. The effect of calcium on growth of rubber trees needs further investigation and it is possible that it may be beneficial in small quantities, *i.e.* in the form of neutral calcium salts, or as lime in quantities which are insufficient to change the soil reaction (pH) to any appreciable extent.

Types of phosphatic fertilisers

Several varieties of phosphates fertilisers are available on the market but little is known regarding the relative effects of these on local soils. The relative merits of soluble and “insoluble” phosphates have been discussed but on the basis of little or no local experimental evidence. The experiments now in progress

have shown that initial dressings of water-soluble phosphates have been slightly more effective than "insoluble" rock phosphates, and of the various forms of "insoluble" phosphates, all have proved equally effective during the first year after application (when used in quantities containing equal amounts of P_2O_5). A comprehensive experiment is in progress which is designed to determine accurately the relative performances of eight varieties of phosphate fertilisers. (P. V. Estate).

Growth records one year after planting

Phosphate treatments		Mean Height ¼ ft. Units	Mean Girth Inches
Rates:—			
1	...	31.0	3.51
2	...	31.3	3.54
3	...	32.9	3.72
4	...	31.6	3.62
Super phosphate	...	33.3	3.80
Basic Slag	...	30.9	3.52
Bone Meal	...	33.0	3.72
Rock Phosphate:—			
Gafsa	...	32.0	3.61
Safaga	...	31.6	3.58
Cheribon	...	30.4	3.45
Egyptian	...	31.0	3.53
Xmas Island	...	31.5	3.58
Average for all forms of rock Phosphate		31.3	3.55

In this experiment superphosphate and bone meal are significantly better than rock phosphate and basic slag; but there are no significant differences between kinds of rock phosphate. Girth of plants treated with the higher rates of phosphate are significantly better than those treated with the smaller quantities, but it is doubtful whether these differences are economically important.

Performance of different clones in new clearings

Only a limited number of the manuring experiments were budded before 1939 and therefore only a few records are available

Growth of Buddings in Manuring Experiments on New Clearings

	Approx. Age	P.B. 86	P.B. 186	Tj. 1	B. 84	D. 65	B.D. 5	G. 1	Tj. 16	P.B. 25	
Estate L. (Selangor)	26 months	15.9	—	—	14.0	15.2	16.0	14.1	—	—	girth (cm.)
" TH. (Johore)	24 "	14.7	15.5	15.7	—	15.5	13.8	—	—	—	" "
" SX. (Pahang)	18 "	12.0	12.9	11.6	11.1	—	11.1	—	—	—	" "
" E. (Pahang)	18 "	13.0	—	12.6	12.5	—	—	—	—	—	" "
" F. (Kedah)	8 "	12.6	11.7	—	10.4	12.6	—	—	11.7	—	height (in.)
" C. (Perak)	12 "	12.5	—	10.9	—	—	—	—	—	—	" "
" Y. (Kedah)	12 "	9.5	—	8.9	—	—	—	—	—	—	girth (cm.)
" SK. (Johore)	12 "	10.2	—	7.6	—	—	—	—	—	—	height (in.) B.S.
" B. (Johore)	6 "	—	8.5	—	8.1	—	—	—	—	—	" "
" P. (N. S.)	6 "	7.2	—	—	5.8	—	—	—	—	—	" "
" SB. (Selangor)	6 "	—	—	7.6	7.2	—	—	—	—	—	" "
											*B.S. = Budded stumps

at this stage for comparison of the response of different clones to manuring. There are indications that some clones respond to manuring better than others; for instance clone P.B. 86 appears to benefit more from manuring than clone Tj. 1. It is only the degree of response that differs, however, and there are no indications yet that different clones require different kinds of manuring.

It is perhaps inadvisable to attach much importance to rate of growth of the different clones in the early stages but the results obtained are of interest and may be stated with the qualification that the relative positions of clones in order of vigour as reflected by the results available may change as the plants get older. Clone Pilmoor B. 84 for instance is known to be a slow grower during the first two years; afterwards with the increase in branch development its rate of growth increases in comparison with other clones.

It is interesting to note that, of the clones used, clone P.B. 86 has proved to be the most vigorous during the first 18 months on the majority of inland soils, clone Tj. 1 almost invariably taking second place. In one centre (TH) clone Tj. 1 has the biggest girth when 2 years old. Clone D.65 has done remarkably well both on alluvial and inland soils while clone B.D.5 has proved to be the most vigorous on a peaty alluvial soil (coastal flat) but is well down the scale on inland soils. The results may be summarised briefly as follows:

C. IMMATURE RUBBER TREES IN REPLANTED AREAS

Results obtained during the period under review confirm earlier conclusions as stated in the last annual report.

There is still little or no evidence of improved growth from manuring of young replanted rubber trees on coastal clay soils and soils derived from volcanic rocks (P.V.S.). On coastal clay in only one experiment is there an indication of a small effect from manuring, nitrogen having given a small but probably significant increase (RS); in general it is not recommended that manures should be applied in replanted areas on coastal clays.

The main effect on inland soils is that of phosphate (except on very sandy soils when potash is just as important) and "insoluble" mineral phosphates are probably as effective as water-soluble phosphate. (R.B. Experiment—Clonal Seeds).

			Height	Girth increments	
			$\frac{1}{4}$ - ft. units	Girth (cm)	in 3 months
Superphosphate	...	...	36.8	7.5	2.8 cms.
Super. + Rock Phosphate	...	...	36.3	7.4	2.8 "
Christmas Island Rock Phosphate	...	...	36.4	7.2	2.7 "
Basic Slag	...	...	35.0	7.1	2.7 "
Nicifos C	...	...	34.0	7.4	2.9 "

Differences are not statistically significant.

R.W. Estate (laterite soil derived from shale)

Phosphate has had a highly beneficial effect in this experiment, increasing the girth of seedlings just before budding by 27.5%, and the height six months after budding by 8%. While an enhanced effect from addition of quantities beyond the minimum amount applied (0.255 oz. P_2O_5) cannot be proved, there are small increases which probably represent real tendencies. It is probable that larger quantities will be very slightly more effective but from an economic point of view the advantage gained is not significant and does not justify the additional expense.

Up to the time of budding, nitrogen improved growth (girth) by about 10%, but had practically no effect on growth during the first six months after budding. Quantities of this nutrient in excess of the minimum dressing (0.269 oz. N) had no additional effect.

Potash had no effect on girth before budding, but it has been demonstrated that it had in this particular instance a significantly harmful effect on growth during the first six months after budding. The adverse effect of potash is generally counterbalanced when it is used with phosphate or nitrogen.

Mixtures of phosphatic fertilisers containing water-soluble and "insoluble" phosphates were not more effective than rock phosphate. Organic manures have given good results, but there is no clear evidence from this experiment that these expensive materials are more effective than equivalent quantities of inorganic manures at about half the cost.

R.C. Estate (alluvial coastal clay soil)

There are no indications that growth of young rubber can be improved appreciably by manuring on this soil type. Growth of the manured trees is generally slightly better than of manured trees but the increase is seldom greater than 5% and is of no economic significance.

R.O. Estate

There are indications that six-monthly manuring is as effective as three-monthly or monthly manuring with equivalent total quantities, both after planting and after budding in the field.

R.B. Estate (undulating granite loam soil)

Phosphate manuring has significantly improved growth, and the effects of potash and nitrogen, although small, may also be judged significant. Different rates of application of phosphate have not affected growth differently and water-soluble phosphate has not proved superior to the less soluble types.

D. TIME OF APPLICATION OF MANURES

Mature rubber trees

No additional information has been obtained regarding the optimum season for manuring mature rubber trees. Growth and yield records show no significant differences, but in so far as the condition of foliage immediately after the wintering next following the application of fertiliser is a criterion of effect there was evidence that April and September manuring were considerably more effective than December manuring.

Effect of fertilisers and time of manuring on budwood and on budding successes

This experiment in which manures are being applied to stocks at varying intervals before and after budding, is in progress at the R.R.I. Experiment Station, and budgrafting is due to take place early in 1940. Growth measurements are being recorded.

III. Cover Plants

Regarding the establishment of creeping leguminous covers under mature rubber trees, whilst more encouraging results have been observed during the past year, particularly on inland soils, the important problem of establishing a cover in all areas of mature rubber is still far from being solved.

On alluvial soils (coastal and inland) establishment of a cover is comparatively easy and on some sedentary inland soils good results have been observed in various parts of the country. There appears to be a relationship between ease of establishment of a creeping cover and the physical properties of soil.

Centrosema pubescens generally does better on local soils than *Pueraria javanica*. Establishment from seeds has proved extremely difficult whereas considerable success has been obtained by using cuttings.

The fertiliser requirements of creeping covers and the benefits of inoculation were discussed fully in the Annual Report for 1938. No further information is yet available.

Results of experiments confirm earlier conclusions regarding the retarding effect of creeping leguminous covers on growth of young rubber trees in replanted areas, and because of competition for moisture and plant food (chiefly moisture) circle-weeding does not appear to be sufficiently drastic during the early stages of growth. The effect of competition is generally much less where clean-weeded strips are maintained and it is recommended that this method of control of covers should be adopted on all young

areas until 6 to 12 months after budding, in combination with a mulching procedure.

Mulching

Measurements support the conclusion that mulching around the rubber plants is highly beneficial during the first year of growth. After the first year, the mulched plants kept their lead but there are no indications so far that the rate of growth is further increased by mulching after the first year. (SG Estate).

	Mulched Plots	Not mulched	Extra girth of mulched plants
Average girth of plants in Nov. 1938 (approx. 12 months after planting)	3.51 in.	3.20 in.	.31 in.
Average girth of plants in Nov. 1939 (approx. 24 months after planting)	6.95 "	6.60 "	.35 "
Girth increments during 2nd year (1938-1939) ...	3.44 "	3.40 "	—

In another experiment also mulching has proved beneficial, trees on mulched plots being on the average 9.4% higher than those not mulched (SR Estate).

The benefits of mulching in the early stages are believed to be largely caused by conservation of moisture in the soil in which the roots are growing, and this practice merits consideration on all areas of young rubber trees—replantings and new clearings.

Comparison of different covers in new clearings

The cultivation of indigenous covers in new clearings is gaining favour, and experiments are in progress designed with the object of comparing the growth of young rubber trees in areas where creeping legumes, shrub legumes, and natural covers are established. In all the experimental areas under consideration one or other of the three types of cover failed to establish in the early stages. Giant snails proved very destructive in some areas while the shrub legumes failed to compete effectively with natural covers which were allowed to regenerate with the object of reducing soil erosion. No reliable conclusions can yet be drawn regarding the relative effects of these covers on the growth of young rubber trees in new clearings other than that creeping legumes tend to retard growth, but it is clear that the cultivation of upright legumes as the sole cover cannot be considered on a large scale as they are comparatively ineffective in stopping soil erosion on hilly land.

Figures showing the relative growth of rubber trees in association with the various covers are presented below but no attempt

is made to draw rigid conclusions from these results since in most cases the conditions aimed at were not fully attained.

Percentage comparison of growth (height)

	Seedlings		Creeping legumes	Shrub legumes	Natural covers
Estate	SB (Selangor)	...	100.0	103.0	106.6
"	SX (Pahang)	...	100.0	90.8	97.2
"	SJ (N.S.)	...	100.0	99.7	95.2
"	SK (Johore)	...	100.0	104.0	109.6
			100.0	102.1	108.6
	Buddings				
Estate	SB (Selangor)	...	100.0	100.6	103.0
"	SX (Pahang)	...	100.0	90.3	96.9
"	SV (Perak)	...	100.0	102.0	104.3

Other experiments in which attempts were made to determine the effect of digging-in the various covers are rather more satisfactory. The retarding effect of creeping covers on the early growth of rubber trees when the control of the legume is limited to clean-weeded circles, is clearly demonstrated. When clean-weeded strips are maintained however the retarding effect almost disappears. Apart from the retarding effect due to competition there are so far no significant differences in growth of the rubber plants in association with the various types of cover plants. Further, no beneficial effect on growth following the digging-in of the loppings of the various covers has yet become apparent.

IV. Soil Management

Under this heading are included experiments designed to study the relative rates of growth of young rubber plants in new clearings on areas where felled timber was (a) burnt in the normal manner, (b) scorched or (c) not burnt. Results obtained during the period under review show no significant differences generally between growth of the rubber plants in the three treatments; in only one experiment (SK) is the growth of rubber distinctly poorer one year after planting in the area where the felled timber was not burnt.

Percentage comparison of growth (height)

Seedlings		Normal burn	Light burn	No burn
SX	...	100.0	106.0	97.5
SV	...	100.0	98.6	108.4
SE	...	100.0	106.8	99.1
H	...	100.0	—	99.5
SB	...	100.0	100.9	109.9
SK	...	100.0	88.0	70.0
		100.0	87.0	69.2 (girth)
Buddings				
SX	...	100.0	106.5	105.3
SV	...	100.0	100.4	108.7
H	...	100.0	—	92.3
SB	...	100.0	97.7	96.3

Percentage comparison of growth of rubber plants with various cover treatments

	Indigenous covers	Indigenous covers + digging-in	Bush legumes	Bush legumes + digging-in	Creeping legumes Circle- weeding	Creeping legumes Strip- weeding	Creeping legumes + digging-in 3-monthly	Creeping legumes + digging-in 6-monthly
Estate SL (Kedah)*	...	100.0	97.4	95.1	84.8	94.1	95.9	88.4
" SCH (")	...	100.0	99.6	110.5	104.7	94.5	103.5	107.1
" SP (Perak)	...	100.0	105.4	97.7	94.3	75.6	102.4	92.2
								87.1

(Differences not statistically significant)

* At this centre the "indigenous cover" is mainly grass.

The second experiment (SCH) is by far the most satisfactory in this series and, in fact, of all the experiments on cover crops).

It will be observed that the present results are not consistent. It appears that relative growth of young rubber trees on burnt and unburnt areas varies according to locality and/or soil type.

V. Laboratory and Pot-Culture Work

Details of analytical work carried out in the laboratory during 1939 are scheduled in the table given below.

Nature of Samples	No. of Samples	No. of determinations
<i>Soil profiles (141)</i>		
(i) Soil Survey and Classification 37 ...	828	14,320
(ii) Soil organic matter changes (S.B.) 54 ...		
(iii) Advisory 50 ...		
<i>Miscellaneous Soil Samples</i> ...	108	286
<i>Plant materials</i>		
(i) Leaf samples from Expt. Station 242	572	5,846
(ii) Rubber seedlings 85 ...		
(iii) Cover crops, miscellaneous leaf samples 245 ...		
Guanos, rubberwood ashes, fertilisers, composts, insecticides, etc. ...	120	1,142
Phosphate fixation and availability ...	—	1,130
	1,628	22,724

(1) *Soil Organic Matter*

(a) Composts

Compost heaps were built at the Experiment Station with the view to determining the usefulness for compost-making of various easily available plant materials and of investigating the effects of aerobic and anaerobic decomposition on the quality of compost. In addition, a heap was made in which potassium permanganate was incorporated in order to study the reported effect of this chemical in accelerating the breakdown of organic debris.

Mikania, *Mimosa* and bamboo were used in separate heaps as the main constituents, mixed with cow-dung and wood ash. The heaps were made in January 1939, and were allowed to ferment for 3½ months, when representative samples were taken from each for analysis. Further details of construction of the heaps and the results of analysis are summarised in the following Tables.

Details of Compost Heaps

Observations taken on 29.4.39.

No.	Plant material Katties	Dung Katties	Ash	KMnO ₄	Plant material	Degree of packing	
1	5589	6354	9 lb.	—	Mikania	loose	Well decomposed.
2	5620	6491	9 lb.	—	Mikania	compressed	Better decomposed than heap 1.
3	5634	1700	9 lb.	—	Mikania	loose	Well decomposed; contains more soil than heaps 1 and 2.
4	300	450	45 Kats.	—	Mikania	compressed	Contains more water; undecomposed parts of Mikania are seen throughout.
5	1942	2413	4½ lb.	—	Mimosa	loose	Not well decomposed. Woody portions of Mimosa remain undecomposed and not likely to decompose for several months. Contains considerably more soil than heaps 1 and 2.
6	2488	2990	3 lb.	—	Mimosa	compressed	
7	1703	—	—	15 oz.	Mimosa	compressed	Woody stems present but less abundant than in heaps 5 or 6. Better decomposed than heaps 5 or 6; contains largest proportion of soil in comparison to all others.
8	2119	2485	9 lb.	—	Bamboo, soft twigs	loose	Contains less undecomposed material than heaps 5, 6, 7 and 9.
9	2069	2492	9 lb.	—	Bamboo, woody stems	compressed	Much of the sample consists of undecomposed woody material which is not likely to decompose for several months.

Analysis of Compost Samples

Sample No.	Reg. No.	Percentage Moisture at sampling	Percentage Ash	Nitrogen Percentage Total	Ammoniacal Nitrogen ppm.	Nitrate Nitrogen ppm.	Percentage P_2O_5 Total	Percentage K_2O Total
1	67	57.2	65.5	1.21	159	159	.881	.52
2	68	59.1	61.8	1.26	186	156	.913	.48
3	69	44.0	78.6	0.66	128	256	.930	.33
4	70	72.4	59.0	1.65	264	169	1.043	.89
5	71	41.1	67.2	0.77	132	168	.463	.27
6	72	42.5	67.9	0.80	141	160	.436	.19
7	73	14.4	88.1	0.28	122	118	.073	.05
8	74	41.9	71.7	0.82	161	187	.422	.13
9	75	43.9	61.2	1.04	164	193	.430	.20

Mikania produced the most decomposed heap and the resulting compost had generally higher contents of plant foods than the others. Under anaerobic conditions higher nitrogen contents usually resulted. The compost produced with potassium permanganate was of poor quality.

The rather variable amounts of soil in the finished products account for the high ash contents.

(b) Soil organic matter changes under covers (S.B. estate)

A series of soil samples, at varying depths, were taken from an estate experimental area where three types of covers (legume creepers, legume bushes, and natural covers) are being used, in combination with three degrees of burning of jungle (no burn, light scorch, and normal heavy burn).

Annual samples are to be taken and changes in organic matter and plant food contents are being studied.

(2) *Nutrition of Rubber Seedlings*

An experiment was carried out at the Experiment Station during the first three months of the year to ascertain the effect of manures on rubber seedlings growing in baskets.

Varying amounts of fertilisers were used, in conjunction with cattle manure and minor elements.

The harmful effect which may be produced by fertiliser application in baskets, as shown by scorching, mortality and reduced growth was estimated, and spectrographic analyses of the plant ashes were made in order to study the distribution of the different elements in the plants.

The results, which are being published separately, indicate the need for considerable caution in applying any fertiliser except rock phosphate in planting baskets.

(3) *Phosphate Studies*

It is well known that most tropical soils are deficient in phosphate, and there is evidence too that much of the phosphate added is rendered immobile or "fixed" in the soil. The importance of phosphate nutrition in rubber cultivation and especially in the cultivation and maintenance of leguminous covers is now well known, and the study of the phosphate status of Malayan rubber soils is clearly of considerable importance.

Much of the work done during the year was preliminary and chiefly of academic interest since it was concerned mainly with the examination of methods suitable for investigating the reaction of local soils to treatment with phosphates, but a few facts of

practical significance have emerged, which can be discussed before the work is fully reported at a later date.

The majority of local soils have a high capacity for adsorbing phosphate and although the adsorbed phosphate is very firmly held by the soil, it is not completely unavailable to plants as is commonly supposed and is permanently "fixed" only in the sense that it cannot be leached away. It has been established that plants can take up a proportion of the adsorbed phosphate. The term "fixed phosphate" has been loosely used for that proportion of phosphate which is held so firmly by the soil that it cannot be leached away with water or dilute acids, but fixation implies complete immobilisation or unavailability and it is suggested that the term "retained phosphate" is more appropriate. When phosphates are supplied to soil they are adsorbed *in toto*, but part is easily and immediately available to plants while a proportion varying from 50 to nearly 100 per cent, depending on soil type and on the depth within the profile, is more firmly held or "retained." This retained phosphate is not so easily available and a proportion of it is undoubtedly permanently fixed and completely unavailable, but the magnitude of that proportion remains to be determined. The phosphate not "retained" is usually termed available phosphate and is determined by standard methods, but this does not necessarily represent the amount available to plants. These methods are arbitrary and for local soils do not give very satisfactory comparisons of the effective phosphate status of the soil; it may be that for purposes of comparing the potentialities of the soil as affected by the phosphate content, the amount of total phosphate in the soil is a better guide.

The degree of phosphate retention varies with depth, generally but not invariably increasing with increasing depth. When applying phosphate to soils we are only concerned with the surface soil and results show that the degree of retention in surface soils varies from 50 to about 95 per cent. In some soils therefore only about 5 per cent of the added phosphate is easily and immediately available to plants although a proportion of the remainder can also be adsorbed gradually.

The degree of retention of phosphate does not increase appreciably with time of contact with the soil, beyond about 20 days.

Further, the degree of phosphate retention in the soil is of the same order for all types of phosphate fertilisers, with the possible exception of Bone Meal; there are indications that a greater proportion of the phosphoric acid in Bone Meal is retained or held more firmly by the soil in comparison with other phosphatic fertilisers.

In investigations carried out to determine the depth in the soil to which phosphate would penetrate when applied on the surface,

over 80% of the added phosphate was retained in the top 1 inch of soil, and it appears therefore that when phosphatic fertilisers are broadcast on the surface of local soils they can be absorbed for the most part only by the roots within the top inch of the soil.

VI. Advisory Work

CORRESPONDENCE

The volume of correspondence decreased slightly, but was still maintained at a high level, 1308 letters being received and 1604 despatched.

The main subjects dealt with were manuring and replanting, and experimental work on estates; a detailed analysis is attached to the Director's report.

VISITS

The number of visits made was 234, including 23 to the Experiment Station; 60% (139) were in connection with experimental work on estates.

INTERVIEWS

Visitors and enquirers received in the Division totalled 110.

LECTURES

The following lectures were given by members of the Division during 1939:—

<i>Venue and Date</i>	<i>Subject</i>	<i>Lecturer</i>
Kajang Branch Incorporated Society of Planters and District Planters' Association at Kajang Club, 14th February	Covers and their effects on Rubber Trees	C. G. Akhurst
Sitiawan Branch Incorporated Society of Planters at Sitiawan Club, 24th February	Organic Manures and Composts	A. W. J. Dyck
Tanjong Malim Branch Incorporated Society of Planters at Tanjong Malim Club, 28th February	Replanting and New Planting	C. G. Akhurst
Malacca Planters' Association at Malacca, 26th March	Cover Crops	C. G. Akhurst
Kulim Branch Incorporated Society of Planters at Kulim Club, 27th June	Organic Manures and Composts	A. W. J. Dyck

To Asiatic Rubber Instructors
at the Rubber Research
Institute, 20th September

Soils in Relation to G. Owen
Rubber Cultivation

Kuala Lumpur Branch Incorporated Society of Planters
and District Planters' Association at Selangor Club,
25th October

Organic Manures and A. W. J. Dyck
Composts

C. G. AKHURST

Head of Soils Division

Kuala Lumpur,

11th April, 1940

**Key to locality of Experimental Centres referred to
by index letters in the text.**

Index Letters.	Estate.	Company.
A	Voules, Tenang, Jo.	Kepong (Malay) R.E. Ltd.
AK	Jabor Valley, Kuantan, Pa.	Bukit Mertajam R. Co., Ltd.
B & BL	North Labis, Jo.	Bikam R.E. Ltd.
C	Banir, Pk.	Banir R.E. Ltd.
CH	Choong Meng, Serdang, Ked.	Selama (Malaya) R.E. Ltd.
D	Rengam, Jo.	Malaya General Co., Ltd.
E	Sungei Kawang, Bentong, Pa.	Sungei Chermang R. Co., Ltd.
F	Victoria, Padang Serai, Ked.	Bikam R.E. Ltd.
G	Prang Besar, Kajang, Sel.	P.B.R.E. Ltd.
H	Mengkibol, Kluang, Jo.	Mengkibol (Central Johore) R. Co., Ltd.
HM	Buan Heng, Scudai, Jo.	South Johore R.E. Ltd.
K	Huntly, Lumut, Pk.	Seafeld R. Co., Ltd.
L	Bukit Rajah, Klang, Sel.	B.R.R. Co., Ltd.
LM	See B.	
M	Juasseh, Kuala Pilah, N.S.	London Asiatic R.&P. Co., Ltd.
N	Sungala, Port Dickson, N.S.	Sungala R.E. Ltd.
O	Ratanui, Teluk Anson, Pk.	Ratanui R. Ltd.
P	Malay Rompin, Seremban, N.S.	Malay R. Co., Ltd.
PM	Sungei Puntar, Bedong, Ked.	Sungei Puntar R.E. Ltd.
PV	United Patani (Malaya) R.E. Ltd., Sungei Patani, Ked.	
R	Rengo Malay, Kluang, Jo.	Bukit Kajang R.E. Ltd.
RB	Kulai Besar, Kulai, Jo.	Consolidated Sango Koshi, Ltd.,
RC	Bukit Cloh, Jeram, Sel.	B.C.R. Co., Ltd.
RO	Cairo, Batang Benar, N.S.	Cairo (Malay) R.Syndicate Ltd.
RS	Sungei Rengam, Batu Tiga, Sel.	Selangor R. Co., Ltd.
RW	Wardieburn, Kuala Lumpur, Sel.	K.L. R. Co., Ltd.
SB	Belata River (Selangor) R.E. Ltd., Kerling, Sel.	
SCII	Chempadak, Gurun, Ked.	Bukit Tupah R.E. Ltd.
SE	Senai, Jo.	Nettai Sangyo Kabushiki Kaisha
SG	Galloway, Banting, Sel.	Klanang P. Co., Ltd.
SK	Sungei Bekok, Bekok, Jo.	Tamiam R.E. Ltd.
SL	Selama, Serdang, Ked.	Sungei Duri R.E. Ltd.
SP	Bruas, Pk.	Amalgamated B.R.E. Ltd.
SR	Rasa, Sel.	Rambutan R.E. Ltd.
SV	Riverview, Batu Gajah, Pk.	R.R.E. Ltd.
SX	Lanchang, Mentakab, Pa.	Chermang Development Ltd.
TH	Tanah Merah, Tangkah, Jo.	T.M.E. (1916).
U & UM	Muar River, Batu Anam, Jo.	M.R.R. Co., Ltd.
V & VM	Sepang, Sel.	London Asiatic R. & P. Co., Ltd.
Y	Tanjong Pau, Jitra, Ked.	T.P.R.E. Ltd.

ANNUAL REPORT

SOILS DIVISION

INDEX

	Page
Advisory work:	81
Correspondence	81
Interviews	81
Lectures	81
Visits	81
Analyses of samples (summary)	76
Application of manures:	
Effect on budwood and budgrafting	72
Rates, phosphate	66
Time	72
Buddings, manuring experiments on new clearings	69
Budgrafting experimental areas	64
Clones, performance in new clearings	68
Coastal Clays:	
Experimental manuring of immature trees	71
Manuring immature trees	65, 66
Manuring mature trees	62
Manuring replanted areas	70
Composts, analysis and composition	76—78
Correspondence	81
Cover plants:	
Comparison in new clearings	73
Competition	72
Digging-in	74
Inoculation of creeping covers	72
Mulching	73
Effect on growth (height)	74
Soil organic matter changes under	79
Weeding	72
Digging-in cover plants	74
Growth of rubber plants:	
Buddings in new clearings (summary)	69
Immature trees in replanted areas	70
Manuring immature trees	64
Manuring mature trees	62
Percentage comparison of immature manured areas	65
Records for phosphatic manures	68
Immature trees in new clearings:	
Manuring experiments	63
Height increments	66
Inland Soils:	
Manuring mature trees	62
Manuring replanted areas	70
Inoculation of cover plants	72
Interviews	81

	Page
Laboratory and pot-culture work	76
Analyses of samples	76
Changes under cover plants	79
Composts	76
Nutrition of seedlings	79
Phosphate studies	79
Lectures	81
Lime, effect of application of	67
 Management, Soil:	
Comparison of growth, normal, light and no burn	74
Growth with various cover treatments	75
Manuring:	61
Budwood and budgrafting	72
Buddings in experimental new clearings	69
Coastal clays—mature trees	62
" "—immature trees	71
Cover plants	72
Experiments on immature trees	63
Field experiments—mature areas	61
Granite loams, undulating	71
Growth, mature trees	62
Height increments, immature trees	66
Inland soils—mature trees	62
Immature areas	64
Laterite soils—immature trees	71
Lime	67
Mature areas	62
Nitrogen, mature trees	62
Phosphate,—mature trees	62
" "—immature trees	66
Potash, mature trees	63
Rates of application (phosphate)	66
Replanted areas	70
Season for	72
Effect of, on yields	63
Mulching	73
 New Clearings:	
Indigenous covers	73
Performance of clones	68
Nitrogen manuring:	
Immature trees	64
Mature trees	62
Replantings	70
Yields	63
Nutrition of seedlings	79
 Phosphate manuring:	
Fertilisers, types	67
Immature trees	64
Mature trees	62
Manuring experiments	66
Manuring in replanted areas	70

	Page
Percentage comparison of growth	67
Studies of "fixation" by the soil	79
Yields with	63
Pot-cultures	76
Potash manuring:	
Immature trees	63
Mature trees	64
Yields with	63
Profiles, soil	61
Replanting:	
Coastal clays	70
Inland soils	70
Visits	81
Yields:	
Nitrogen manuring	63
Potash manuring	63
Phosphate manuring	63

ANNUAL REPORT *

BOTANICAL DIVISION

Staff and Organisation

There has been no increase in the senior staff of the Division during the year, but three laboratory assistants were engaged.

No changes have been made in the allocation of the work of the Division among the graduate staff (see Annual Report for 1938, p. 59) other than those necessitated by absences from Malaya on long leave.

Mr. C. E. T. Mann, Head of the Botanical Division, who acted as Director during Mr. Page's absence on leave, went on long leave on 29th July, 1939.

Mr. C. C. T. Sharp returned from long leave on 27th June and was appointed to act as Head of the Botanical Division during the absence of Mr. Mann.

I. Vegetative Propagation

(1) METHODS OF PROPAGATION AND PLANTING

Propagation of Stocks

Investigations into the use of a wide range of growth-promoting substances in the propagation of *Hevea* by cuttings were continued during the year and an account of some of these experiments has been published (Baptist, *J.R.R.I.M.* **9**, 17-39).

In addition to the experiments already described many more were carried out on cuttings of seedlings and buddings. The cuttings were taken at different seasons of the year from hard and soft wood with and without leaves, but in no case could they be induced to take root.

Experiments with leaf cuttings were equally unsuccessful.

It must be concluded that although cuttings taken from the main stems of young seedlings have been rooted successfully, *Hevea brasiliensis* must be classed with the numerous other species of plants for which no satisfactory method of propagation by cuttings has been devised.

Treatment of "Stump" plants prior to Transplanting

Experiment No. 1 (Field 6A)

An experiment was set up in Field 6A of the R.R.I. Experiment Station in March 1939 to compare the effect of different degrees

* An index follows page 155.

of root pruning and treatment with growth substance on the establishment and subsequent growth of budded stumps. Five lengths of lateral roots were used, namely, 0, 1, 3, 6 and 12 inches and of the hundred stumps in each series fifty were treated with a proprietary growth substance for 24 hours and the other fifty were untreated.

Treatment with growth substance hastened the appearance of the scion shoot in all series and this initial advantage was maintained in the growth in length of the shoot up to six months after planting. Thereafter, however, the lead was not maintained and the latest measurements, taken nine months after planting, showed little, if any difference in favour of the treated stumps with lateral roots pruned at 0, 1 and 3 inches from the tap root, while the growth of the scion shoot on stumps with lateral roots pruned at 6 and 12 inches was actually slightly retarded as a result of the treatment.

The beneficial effect of growth substance on the establishment of transplanted stumps is greatest in the case of stumps completely deprived of lateral roots where the percentage of mortalities was reduced from 58 per cent to 8 per cent. Corresponding figures for stumps with lateral roots pruned 1 inch from the tap root were 28 and 8. This effect of growth substance disappeared almost completely when the lateral roots had been pruned at 3, 6 and 12 inches from the tap root.

From a consideration of the growth data obtained nine months after planting it is concluded that, under the conditions of the experiment, budded stumps with lateral roots three to twelve inches long derive little or no benefit from treatment with growth substance, as regards both successful transplanting and subsequent growth of the scion shoot; the best results were obtained with *untreated* stumps with the lateral roots of the main whorl pruned at six inches from the tap root.

The stumps in this experiment have been placed into two groups according to size, "small" stumps with a girth of less than five inches ($3\frac{1}{4}$ to $4\frac{3}{4}$ inches) and "large" stumps with a girth of five inches and over (5 to $7\frac{3}{4}$ inches).

The average height of the scion shoot in both groups nine months after planting is shown in Table I.

For *small* stumps the growth was better when treated with growth substance at lengths of lateral root below 12 inches, but *large* stumps, no matter what root length, grew better if untreated.

Moreover, the results taken as a whole show that stocks $1\frac{1}{2}$ to $2\frac{1}{2}$ inches in diameter make better growth than stocks 1 to $1\frac{1}{2}$ inches in diameter.

TABLE 1. *Effect of growth substance on growth (9 months) of budded stumps*

Lateral roots		Length of lateral roots in inches											
		0		1		3		6		12		Mean all lengths	
Size of stumps		small	large	small	large	small	large	small	large	small	large	small	large
Treat- ment	with growth substance	46.4	43.4	44.1	53.2	48.8	58.4	57.5	55.5	40.5	59.7	47.5	54.0
	no growth substance	40.0	48.6	44.4	56.5	41.8	58.6	47.3	59.7	47.9	63.2	44.3	59.3

Experiment No. 2 (Field 4B)

Another experiment was set up in Field 4B in late December 1938 to compare the effects of treatment with growth substance, and of time of manuring on the growth of budded stumps with and without lateral roots.

The fertiliser was applied at the rate of 5 oz. per point; at the time of planting (in the planting hole, or on the surface), at three months and at six months after planting.

The data obtained one year after planting show that the retention of a short length of lateral roots (3") has in all cases resulted in better growth of the scion shoot. Treatment with growth substance has proved beneficial only in the case of stumps manured 3 months after planting and has, in the presence of lateral roots, actually depressed the growth of the scion shoot of the stumps manured on the surface at the time of planting. The unmanured stumps, whether with or without lateral roots, showed no effect from treatment with growth substance.

These results should be accepted with caution since the statistical analysis of the data was not available in time for inclusion in this report.

Experiment No. 3 (Field 6A)

In collaboration with the Soils Division.

Budded stumps of clone Pilmoor B. 84 with tap roots pruned at 2 feet from the collar and lateral roots of the main whorl pruned at 2 inches from the tap root were planted on April 4th, 1939. All stumps were treated with growth substance prior to transplanting. The manuring scheme compares the standard initial

dressings of Sterameal (N, 7%; P_2O_5 , 10%; K_2O , 5%) and R.R.I. (1938) Mixture E (N, 10.3%; P_2O_5 , 17.5%; K_2O 6.4%). The amounts do not contain equivalent quantities of N, P and K.

Manuring Scheme

I. $\frac{1}{2}$ lb. Sterameal	} Mixed in bottom foot of $2 \times 2 \times 2\frac{1}{2}$ ft. hole at planting.
II. $2\frac{1}{2}$ oz. R.R.I. (1938) mixture	
III. $\frac{1}{2}$ lb. Sterameal	} incorporated in top 9 inches of hole at planting.
IV. $2\frac{1}{2}$ oz. R.R.I. (1938) mixture	
V. $\frac{1}{2}$ lb. Sterameal	} scratched in a circle from 2 to 12 inches around stump at 3 months.
VI. $4\frac{3}{4}$ oz. R.R.I. (1938) mixture	
VII. $4\frac{3}{4}$ oz. R.R.I. (1938) mixture	} scratched in a circle from 2 to 12 inches around stump at 5 months.
VIII. Control (unmanured)	

Results at nine months after planting are shown in Table II.

TABLE II. *Effect of manuring budded stumps*

Treatment	I	II	III	IV	V	VI	VII	VIII
Number dead ...	2	2	1	3	2	0	3	0
Number alive (bud shot)	25	26	26	24	24	27	25	27
Average height of scion after 9m. (in inches)	69.0	58.0	61.7	58.3	64.1	66.3	53.6	40.6

All fertiliser treatments have increased the growth of the scion shoot. The statistical significance of these results has not yet been ascertained.

(2) STOCK-SCION RELATIONSHIPS IN BUDDINGS

Study of Seedling Root Systems

Experiment No. 1 (Field 6A)

A quantitative determination of root concentration at different depths has been completed. Soil cores were taken out in one foot lengths down to a depth of eight feet by means of a boring tool consisting of a metal tube 10 ft. long and 4 inches internal

diameter, fitted with a cutting shoe of hard steel. The roots in each foot of soil were washed and their dry weight recorded.

The results together with those of the qualitative investigations referred to in the Annual Report for 1938 will be published in the Institute's Journal.

Clonal Seedlings as Stocks for Budding

(a) Four families of illegitimate clonal seedlings were planted in field 14E (1) in November 1931. In December 1932 half the trees were budded with P.B. 186 and the remainder were left unbudded. Tapping of the unbudded trees commenced in 1937 and of the budded trees in 1938 and the girths and yields for 1938 and 1939 are set out in Table III.

There are only small differences in the girths and yields of the four families of seedling trees.

The highest-yielding budded trees are those budded on to the highest-yielding family of seedlings (B. 58) and the lowest-yielding buddings are those made on to the lowest-yielding family of seedlings, but the differences are in all cases quite small.

TABLE III. *Growth and Yield of illegitimate Clonal Seedlings and of Buddings made on Seedling Stocks of the same Families*

Seedling Families	Seedlings						Buddings (P.B. 186)					
	No. of Trees		Mean Girth Inches		Mean Yield in gm. per tapping		No. of Trees		Mean Girth Inches		Mean Yield in gm. per tapping	
	1938	1939	1938	1939	1938	1939	1938	1939	1938	1939	1938	1939
A.44	100	102	29.6	31.6	18.0	22.3	41	56	21.5	23.0	10.8	11.0
B.50	105	103	30.2	32.3	17.4	21.0	55	68	22.1	25.0	11.2	12.1
B.58	144	144	30.5	32.5	20.6	23.9	72	144	21.6	23.3	12.1	12.6
M.A.P.	106	105	29.5	32.3	15.4	19.1	40	75	21.4	22.0	10.6	10.7

(b) Illegitimate seedlings from clones Tjirandji 1, Prang Besar 23, Pilmoor B. 84 and Avros 256 were planted in Fields 28 and 29 of the Experiment Station in October 1935 and budded in November 1936 with clones Tjirandji 1, Prang Besar 23, Pilmoor B. 84, Glensheil 1 and Pilmoor D. 65. Every sixth tree was left unbudded.

The mean girths in inches, at 40 inches from the union (buddings) or from the ground (seedlings) are shown in Table IV.

TABLE IV. *Growth of Buddings on Clonal Seedling Stocks*

Origin of Seedlings	Mean Girth of Seedlings inches	Mean Girth of Buddings (all clones) inches	Mean Girth of Buddings of the different Clones—inches				
			Tj.1	P.B.23	Pil.B.84	G.1	Pil.D.65
Tj.1	16.4	9.8	10.8	9.8	9.7	10.3	8.3
P.B.23	14.9	9.9	10.9	9.6	9.9	10.0	9.3
Pil.B.84	14.3	9.8	10.7	9.7	9.9	9.7	8.9
Av.256	15.0	9.3	10.2	9.5	9.3	9.4	8.1
Mean Girth of different Clones			10.6	9.6	9.7	9.8	8.6

The results, three years after budding, show no advantage in growth of the buddings made on illegitimate seedlings of the same clone.

The growth of the buddings is poorest on stocks of Avros 256 seedlings. There is no evidence from this experiment that the vigour of the stocks has had any effect on the vigour of the buddings made on to them.

Experiments with "Twin" Plants

Series I, (Field 4C). Planted in baskets in March 1930. One member of three out of every four pairs of twin plants was budded in April 1932.

Series II, (Field 25 III). Planted in the nursery in May 1931 and planted in the field as stumps in November 1932. Not budded.

Both series were tapped throughout the year alternate-daily on a half circumference spiral cut ($S/2, d/2, 100\%$) and the yields of the individual trees were recorded by cup coagulation on two tapping days in every month.

In both series the height of the tapping cut was about eleven inches from the ground at the end of the year.

The yields and girths of the unbudded pairs of trees are summarised in Table V.

TABLE V. *Comparison of Growth and Yield of Twin Seedlings*

Series	No. of Pairs	Girth at a height of 40" from ground in ins.		Yield in gm. per tapping	
		a—member	b—member	a—member	b—member
1. Field 4C	30	27.6	25.9	27.1	24.5
2. Field 25 iii	56	21.1	21.0	18.2	17.5

The correlation coefficients between the girths of the a and b-members of the twins are +0.65 and +0.66 for the two series respectively. Since conditions of growth and development in the field cannot be entirely uniform and may even vary considerably, the above values of correlation coefficients may be considered sufficiently high to demonstrate the close agreement in growth between the two members of a pair of twins.

Yields were expressed, as in 1938, on the basis of yield per inch of tapping cut. This partly compensates for differences in growth of the two members of a twin caused by variations in soil and position. The values of the correlation coefficients for yield per inch of tapping cut of the a and b-members of twins are +0.72 for the first series and +0.81 for the second series.

TABLE VI. *Twin Trees Series 1. Girths and Yields of Budded and Unbudded Trees*

Clone budded on a—members	No. of Pairs	Girth at height of 40 ins. in inches		Yield in gm. per Tapping	
		a—member (budded)	b—member (not budded)	a—member (budded)	b—member (not budded)
P.B.186	13	23.2	27.6	21.5	23.7
Tj.1	12	25.8	26.3	32.2	24.2
B.D.5	5	21.2	28.3	16.4	25.3
Pil. D.65	8	24.6	27.6	28.6	22.1
All Clones		24.0	25.7	27.3	24.0

The yields and girths of the budded and the unbudded members of twins in series 1 (field 4C) are summarised in Table VI. The tapping cuts passed the union towards the end of 1939 and were approximately 1 to 2 inches below the union at the end of December.

The correlation coefficient between yield per inch of tapping cut of the budded a-members and the unbudded b-members is +0.25, exactly the same value as obtained in 1938, indicating that there is no close relationship between the potential yield of the stocks and the yields of the scions grafted upon them.

In Series I the girths of the unbudded members of each pair were measured at six inches from the ground and those of the budded members at 40 inches from the ground on the scions and at six inches from the ground on the stocks (Table VII).

TABLE VII. *Twin Trees Series 1. Girth Measurements in Inches*

a—members budded with clone	No. of pairs of twins	b—members not budded. Girth at 6 ins.	a—members budded. Girth of:—	
			Stock at 6 ins.	Scion at 40 ins.
P.B.186 -	16	35.3	33.4	22.8
Tjirandji 1 -	18	33.8	37.1	24.7
B.D.5 -	9	36.0	30.8	20.1
Pil.D.65 -	9	34.3	33.4	22.7

It is clear from Table VII that the vigour of growth of the scion has a large effect on the rate of growth of the stock on which it is budded.

The position is clarified by consideration of the values of the correlation coefficients. It has been shown above that the correlation between the girths of the two members of a pair of unbudded twin seedlings is +0.65. But it is found that the correlation between the girth of the unbudded member and the girth of the stock of the budded member of each pair of twins is reduced to +0.11. On the other hand the correlation between the girth of the scion and the girth of the stock on which it is budded is very high at +0.78.

It may be concluded from this that by the ninth year of age the vigour of growth of the scion is the important factor in

determining the growth of a budded tree and that the vigour of the stock has little or no effect. These results have been obtained from four clones budded on to two families of seedlings and may not be applicable to all combinations of scion and stock.

Series III. A further series of twin *Hevea* plants were established in field 22B. These were produced from illegitimate seedlings of five Malayan clones between October-December 1930 and planted out as stumps in November 1932. In September 1934 buddings were made on the a-members of the twin plants leaving unbudded about 36 pairs of each family as controls. In July 1935, all the unbudded seedlings were pollarded at a height of about 8 feet from the ground. This experiment is to be tapped from January 1940.

Girth measurements at forty inches from the ground were taken in December. The difference in growth of the unbudded families of seedlings is small and there is insufficient evidence to show that such differences in vigour have had any effect on the vigour of the scions budded on to similar seedlings (Table VIII).

TABLE VIII. *Girth of Budded and Unbudded Members of Twin Seedlings (Series 3)*

Illegitimate Seedlings of Clone	Both members not Budded		a—members budded with clone:—					
	a	b	a P.B. 186	b not budded	a B.84	b not budded	a Avros 50	b not budded
M.A.P.	20.6	20.2	16.1	20.2	18.5	19.3	17.7	23.1
A.44	20.0	20.7	17.6	22.8	18.5	22.3	—	—
S.R.9	20.9	20.9	17.2	21.7	17.8	20.0	18.0	20.7
P.B.24	19.9	20.8	16.5	22.4	20.0	21.8	—	—
P.B.20	21.2	19.3	17.2	20.7	19.6	21.8	17.5	22.0
Mean	20.5	20.4	16.9	21.6	18.9	21.0	17.7	21.9

The correlation coefficients between the girths of the budded and unbudded trees in the various combinations of scion and stock are set out in Table IX.

TABLE IX. *Correlation coefficients between girth at 40 inches from the ground of budded and unbudded members of twin plants*

b—members (not budded) Illegitimate Seedlings of Clone	a—members of twin seedlings budded with:—					
	Clone P.B.186		Clone B.84		Clone Avros 50	
	No. of Pairs	Coefficient of Correlation	No. of Pairs	Coefficient of Correlation	No. of Pairs	Coefficient of Correlation
M.A.P.	27	+ 0.35	19	+ 0.65	22	+ 0.42
A.44	25	+ 0.42	23	+ 0.62	—	—
S.R.9	23	+ 0.23*	22	+ 0.62	21	+ 0.84
P.B.24	22	+ 0.25*	27	— 0.13*	—	—
P.B.20	20	+ 0.55	17	+ 0.50	—	—

* These correlations do not reach the 5 per cent level of significance.

The correlation coefficients between the girth of the a and b members of 126 pairs of unbudded twins of the five families of illegitimate seedlings combined is +0.65. This is the same value as that found in the first two series and again shows that there is a close relationship between the rate of growth of the two members of a pair of twins.

In the case of the pairs of twins of which the a-member has been budded there is a significant positive correlation in nine out of the twelve combinations of scion and stock, showing that in three-quarters of the cases there is a definite relationship between the vigour of the stock and the vigour of the scion budded on to it.

The only combination of scion and stock common to the first and third series is that of P.B. 186 budded on to illegitimate seedlings of A. 44. In the first series there is no significant correlation between the girth of scion and stock in this combination but in the third series there is a significant correlation of +0.42.

The explanation of this discrepancy in the correlations in the first and third series is uncertain, but it may possibly be accounted for by the difference of two and a half years in the age of the two series. If this should be the case the correlations in the third series may be expected to diminish and eventually disappear in the course of the next few years. It would also appear from the variations in the correlation coefficients that the

rate at which the effect of the stock on the growth of the scion disappears will be greater in some combinations than in others.

Influence of Scion on Yield of Stock in High-budded Trees

(a) The experiment in field 10 described in the Annual Report for 1938 (p. 65) has been continued and the yields for the second year of tapping are summarised in Table X.

TABLE X. *Tapping of High Buddings. Influence of Scion on Stock*

Group	Height of union from ground; inches	Height of tapping cuts above union		Yield in gm. per tree per tapping during 1939					
		on 1/1/38 inches	on 31/12/39 inches	Av.50	Av.152	S.R.9	P.B.186	All Clones	Seed-lings
A	2	+ 20	+ 5.9	23.5	19.9	19.9	21.8	21.3	—
B	12	— 10	— 3.8	18.9	16.2	17.3	23.7	19.0	—
C	24	0	— 17.4	19.5	24.7	17.1	19.6	20.2	—
D	36	— 10	— 23.5	16.4	17.2	15.3	15.9	16.2	—
E	48	— 20	— 33.3	18.2	17.4	13.2	16.4	16.3	—
F	48(1)	24(2)	7.8	—	—	—	—	—	20.9
Mean girth at 24 inches ...				33.0	31.8	31.8	32.3	—	36.6

(1) Pollarded at 48 inches from the ground

(2) Measured from ground level.

During the year group A was tapped on the scion and group B partly on the stock and partly on the scion. Groups C, D and E were tapped entirely on the stock. The tapping cuts were all at the same height from the ground, yet the yield of group C was about 25 per cent higher than those of groups D and E. It may be concluded from this that the scions have had the effect of increasing the yield of the stocks on which they were budded but that the effect diminishes and possibly disappears altogether as the distance of the tapping cut below the union is increased.

(b) The experiment with high budded trees on an estate was discontinued after the second year of tapping was completed. It is hoped to resume the experiment after some years when tapping will be carried out on renewed bark below the union.

TABLE XI. *Summary of Yield Records of Budded Trees*
(*Yields of trees tapped alternate-daily on*

Field No.	Area in acres	Description of Field
5	40	Planted in November 1929 with budded stumps in monoclonal plots of 121 points (11 rows x 11). Original stand: 108 trees per acre. Randomised block clone trial with 4 replications; plot centres (9 rows x 9) split for 3 tapping treatments in 1938. Age at commencement of tapping (Jan. 1936): 6 years.
10	10	Planted in February 1929. Budded at different heights (from collar to 48") from October 1931 to December 1932. Records from trees budded at normal height only. Age at commencement of tapping (Jan. 1938): 6½ years.
17A	10	Planted October 1929. Budded December 1930. Interplanted April 1930 with unselected seedlings. Original stand 180 trees per acre in equal proportions of budgrafts and seedlings; stand reduced in 1937 to 125 trees per acre (86 buddings and 39 seedlings). Age at commencement of tapping (Jan. 1936): Budgrafts 5 years; Seedlings 5½ years.
17C	4½	Planted October 1929. Interplanted with stumps November 1930. Budded October 1931. Stand 180 trees per acre in equal proportions of Av.50 & D.65. Age at commencement of tapping (Jan. 1938): 6½ years.
17D South	10	Planted October 1929. Budded April 1931. Interplanted April 1930 with unselected seedlings. Original stand 180 trees per acre in equal proportions of budgrafts and seedlings; stand reduced in July 1938 to 125 trees per acre (75 buddings and 50 seedlings). Age at commencement of tapping (Jan. 1937): Budgrafts 5½ years; Seedlings 6½ years.
21	25	Planted in December 1929. Budded in October 1931 (polyclone budding in regular succession). Original stand 90 trees per acre. Randomised block tapping experiment with 6 replications of 4 treatments set up in 1938. Age at commencement of tapping (Jan. 1936): 4½ years.
22A North	10	Planted in December 1930. Budded in December 1932 (polyclone budding in regular succession). Original stand 90 trees per acre. Age at commencement of tapping (Jan. 1938): 5 years.

on the R.R.I. Experiment Station, Sungei Buloh
half-spiral cut only)

Clone	Tappable Trees (percentage)				No. of Trees tapped a.d. (1939)	Yield in lb. per tree per year (160 tappings)				Wind Damage (per- centage) To end of 1939	Brown Bast (per- centage) 1939
	1936	1937	1938	1939		1936	1937	1938	1939		
Avros 49	63	84	88	91	76	4.6	6.5	8.9	9.8	—	—
Avros 50	64	97	97	98	83	4.5	7.0	8.8	10.4	—	—
Avros 152	59	80	84	89	87	3.7	4.8	5.9	6.5	0.9	0.6
B. D. 5	18	75	93	95	85	4.1	5.3	6.6	7.3	0.5	—
Pil. A. 44	75	94	97	99	75	8.1	9.0	9.5	9.8	7.1	5.0
Pil. B. 84	86	98	98	98	88	5.8	8.5	9.2	10.2	0.6	0.6
P. B. 23	57	83	90	91	77	4.9	7.7	8.8	10.1	—	1.3
P. B. 186	74	88	99	99	85	4.9	8.1	9.5	11.2	1.5	0.6
Tj. 1	76	89	94	94	89	7.4	10.2	12.2	13.9	2.3	3.9
Avros 50			66	83	25			4.5	7.3	2.0	—
Avros 152			63	77	23			6.1	6.6	—	—
P. B. 186			70	73	22			5.4	7.3	5.0	—
S. R. 9			30	40	12			4.3	6.3	—	—
Avros 50	10	34	50	67	92	3.1	3.8	5.3	6.2	—	—
Avros 183	9	29	37	51	73	6.4	7.7	9.1	9.7	0.7	—
Avros 185	18	48	65	73	101	8.0	8.1	8.8	8.7	3.1	—
Glen. 1	26	44	57	68	99	6.4	7.6	9.2	10.0	—	2.0
Tj. 1	51	63	68	82	108	6.7	9.3	12.7	16.7	6.4	0.9
Tj. 16	16	39	52	62	85	6.4	7.4	8.3	9.3	—	—
Seedlings	79	100	100	100	384	3.2	4.9	5.4	6.6	1.3	0.2
Avros 50			48	68	235			3.5	4.9	0.3	0.4
Pil. D. 65			56	64	218			3.7	6.5	0.3	1.8
Avros 50		23	41	53	67		3.7	3.8	5.6	—	—
Glen. 1		21	30	45	56		6.1	6.7	7.5	1.5	—
Rub. 393		24	37	50	59		2.9	3.4	5.4	—	—
Sab. 24		22	36	50	58		4.0	4.8	7.7	—	—
Tj. 1		45	50	64	81		7.2	7.1	9.5	2.0	—
Tj. 16		17	28	36	43		6.5	6.3	8.2	0.7	—
Seedlings		70	84	91	412		3.6	4.4	6.7	0.4	0.2
Avros 50	22	53	69	75	48	2.9	4.8	7.2	9.6	1.5	0.6
Avros 71	47	59	67	72	41	3.6	6.1	8.4	9.7	8.6	—
Avros 256	21	43	57	68	42	2.3	3.0	3.8	5.6	0.3	—
B. D. 10	40	55	72	77	45	3.5	6.5	7.8	10.3	5.9	—
Ct. 88	40	59	70	79	47	4.5	6.5	8.5	10.3	3.0	0.4
S. R. 9	9	25	42	59	32	2.9	4.8	5.8	6.8	0.6	—
Tj. 16	10	35	43	58	38	6.3	8.3	9.4	10.5	2.7	—
Avros 49			35		60			5.0	5.7	—	—
Avros 152			32		56			4.2	4.6	—	—
P. B. 186			33		54			4.3	6.3	1.8	—
Rub. 393			42		68			4.0	6.9	—	—
Tj. 1			47		67			7.5	11.6	9.1	—

(3) GROWTH AND YIELDS OF BUDDED TREES

Comparative Trials of Clones at Sungei Buloh

Regular tapping of proved clones continued in Fields 5, 10, 17A, 17C, 17D (South), 21 and 22A (North). The principal data are summarised in Table XI, which gives the yields of the trees tapped on the standard system (S/2,d/2,100%). Comparative yields on various tapping systems are given in the second section of this report (p. 108).

The percentage of windbreaks is calculated on the total number of trees of each clone in all plots regardless of tapping system; it includes trees damaged both prior to (vide Table VI in 1938 Report) and during 1939. The percentage of trees affected by brown bast disease represents the average number of trees out of tapping throughout the year and is calculated on the trees tapped at 100% intensity on the standard system only.

Heavy supplying took place in Field 5 during 1930 and 1931 and the percentage of tappable trees is estimated on only those trees of the original planting which still survive. The amount of supplying necessary in Fields 17, 21 and 22 was small, and the percentage of tappable trees is estimated on all trees and not on the original planting. In Field 10, although fairly heavy supplying took place, the percentage of tappable trees is also estimated on the total number.

After further reductions, by removal of diseased and wind-damaged trees, the respective stands in Fields 17A and 17D are now 122 (83 budgrafts and 39 seedlings) and 118 (73 budgrafts and 45 seedlings). The heavier thinning out of the seedling trees in Field 17A in 1937 (on yield) tended to raise their mean yields in comparison with the budgrafts and also accounts for the sudden jump to 100 in the tappable percentage.

The yields of the clones tested call for no particular comment. The yield of clone Tjirandji 1 in Field 17A is outstanding and approaches 50 grams per tapping; this clone is also the highest yielder in Fields 5, 17B and 22A. A number of other clones have done satisfactorily on the poor soil of the Experiment Station, including Tjirandji 16, Glenshiel 1 and Pilmoor B. 84. The yield of Prang Besar 186 is high, but this clone is not generally recommended for commercial planting owing to defects in its secondary characters.

The general rates of increase in yield in 1938-39 have been even poorer than in 1936-37. This is attributed to the exceptionally dry weather of the last two years which has adversely affected certain clones, notably Pilmoor B. 84.

TABLE XII. *Density-of-Planting Experiment (Field 14 C & D, K.R.I. Experiment Station)**Planted: December 1930 with budded stumps of Clone Acres 50*

Plot Index	Planting Distance in feet	No. of Trees per acre	Girth Measurements								Yield Data for 1937, 1938 and 1939								
			Mean Girth in inches at the end of each year of life								Per Cent Trees Tapped		Yield in lb. per tree		Yield in lb. per acre				
			2	3	4	5	6	7	8	9	1937	1938	1939	1937	1938	1939	1937	1938	1939
A	30 x 30	48	4.8	8.0	12.1	16.4	19.3	21.5	25.5	28.0	75	91	93	5.7	7.5	10.1	261.3	324.0	496.8
B	20 x 20	109	5.1	8.3	12.1	16.3	18.7	19.1	21.0	22.2	64	74	79	5.7	5.8	6.7	345.8	458.1	647.1
F	20 Δ	125	5.1	8.2	12.1	15.5	18.1	18.8	20.8	22.0	61	76	83	5.0	5.7	6.4	344.9	511.2	655.1
C	14 x 14	222	4.9	7.8	11.5	14.8	17.1	17.3	18.8	19.4	51	65	72	4.2	4.0	4.9	421.2	563.9	816.1
D	12 x 12	302	5.1	8.2	11.7	14.2	15.9	15.6	17.0	17.5	39	53	62	3.7	3.6	4.0	384.7	539.2	800.2
E	10 x 10	435	5.2	8.1	11.1	13.2	14.7	14.1	15.4	15.9	20	34	48	3.9	3.5	3.4	262.6	463.6	742.0

Note. Girth measurements.

Up to the 6th year, all trees in each plot were measured ... Each plot = 1.1 acres

After the 6th year, boundary belts are excluded from the records ... Each plot = 0.65 acres

Influence of the Density of Planting on the Growth and Yield of Budded Trees

Summaries of the growth and yield records for 1939 in the density-of-planting experiment in Fields 14 C & D at the Experiment Station are given in Table XII.

The highest yields are still recorded in the C-plots planted at 222 trees per acre, though the yields of the other more densely planted plots continue to increase at a greater rate as new trees are brought into tapping on reaching the required minimum girth.

In the E-plots, planted at 435 trees to the acre, the rate of increase in yield is most striking. The average yield per tree has however decreased slightly which can be accounted for by an

TABLE XIII. *Density-of-Planting Experiment*

*Bark measurements in millimetres. Clone Avros 50
Age of trees—9 years*

Plot Index	Planting Distance in feet	No. of trees per acre	Mean Bark Thickness (mm.)			
			Virgin bark	Renewed Bark after (years) (percentage of virgin bark)		
				1	2	3
A	30 x 30	48	9.02	6.36 (70.5%)	7.34 (81.4%)	8.10 (89.8%)
B	20 x 20	108	8.04	5.74 (71.4%)	6.66 (82.8%)	7.31 (90.9%)
F	20 $\triangle$	125	7.78	5.47 (70.3%)	6.37 (81.9%)	7.02 (90.2%)
C	14 x 14	222	6.66	4.73 (71.0%)	5.54 (83.2%)	6.08 (91.3%)
D	12 x 12	302	6.47	4.53 (71.6%)	5.22 (80.7%)	5.67 (87.6%)
E	10 x 10	435	6.10	4.37 (71.6%)	5.24 (85.9%)	5.74 (94.1%)
Stand- ard error	—		.115	.121	.138	.131

increase of over forty per cent in the number of trees tapped compared with eleven per cent in the C-plots.

It should be noted that the higher yields per acre in the more densely-planted plots do not necessarily represent an economic gain, owing to greatly increased cost of tapping.

The reduction in the rate of increase in girth in the more densely planted plots is becoming steadily greater as the experiment progresses. In the plots planted at over 200 trees to the acre the increase in girth in 1939 is only half an inch compared with an increase of two and a half inches in the A-plots planted at 48 trees to the acre. In the plots planted at 109 and 125 trees to the acre a satisfactory increase in girth of just over one inch occurred.

At the end of the year the first set of bark measurements were taken. (Table XIII).

The bark thickness measurements recorded in the foregoing table represent the means of 30 trees in each plot i.e. 180 trees per treatment. The differences due to planting density are highly significant. It will be noted that the rate of renewal is approximately proportional to the thickness of the virgin bark. Taking 6 mm. as the minimum tappable bark thickness, it would appear that even in the plots planted at 10×10 , bark renewal will be adequate by the time it comes to be tapped.

(4) YIELDS OF BUDDED RUBBER IN COMMERCIAL TAPPING

Continuing the enquiry started in 1938 a more detailed questionnaire was circulated to estates in April. By the end of the year returns from over 650 areas of budded rubber in commercial tapping had been received.

It has not been found possible to give within the compass of an Annual Report an account of the data received and a full discussion of the records received up to the end of 1939 will appear in the *Journal*.

II. Tapping Investigations

A large number of tapping experiments have been laid down during the year and the first tapping results of fifteen new experiments are published in this report. When comparing the yields of different tapping systems in experiments which have lasted for only a short time it is well to recollect that the later results from some of those systems, particularly those in which the tapping cuts completely encircle the tree, may differ widely from those

published here for the first time. The early yields, though interesting in themselves are unimportant compared with the general trend of the yields over a period of years.

The revised international tapping notation is followed throughout (Guest 1940 *J.R.R.I.M.* **10** 16-33, Communications 246 and 247). Since it is probable that there are many who are not yet fully acquainted with the new terms, the old description of the tapping systems is also given.

When preliminary yields were recorded before beginning experimental tapping the figures for relative yields of the various treatments are usually adjusted in proportion to the preliminary yields of the respective plots. Apparent discrepancies in some of the tables between actual yields, which have not been adjusted, and adjusted relative yields may be accounted for in this way.

The age of the seedling trees is reckoned from the date of planting and of the budded trees from the date of budding where budding in the field was done* or from date of planting as budded stumps. For example, if in the table the year of age is given as the tenth, it means that the mean age of the trees during the period under review lay between the ninth and tenth anniversaries of the date of planting or budding or planting as budded stumps.

(1) TAPPING EXPERIMENTS ON SEEDLING TREES

A. *Continuous Alternate-daily tapping and A.D., A.B.C. tapping with resting periods of two, four and six months. Tapping Experiments Nos. 21 to 26*

For this series of six experiments on seedling rubber 20-25 years old the first tapping year was completed on 31st October 1939. The yields of the controls and the relative yields on the three 67 per cent periodic systems, are tabulated below (Table XIV).

The sites chosen for these six experiments were selected according to their previous yields to represent types of rubber yielding from 300 to 600 pounds per acre when tapped C 2.d 2.100%. The actual range of yields recorded during the first year is very much smaller, a result which can partly be accounted for by the position of the tapping cuts during the first year which averaged 45 inches above the ground. The range will probably increase as the cuts get lower.

The yields of the control plots in the different experiments are not in the expected order; for instance, Experiment No. 25 which was supposedly laid out on the poorest area gave the fourth highest yield whereas Experiment No. 22 which should according to its previous yield have been third in order of merit, gave the

*This convention differs from that mentioned in *J.R.R.I.M.* (1939), 9, p. 157

lowest yield of all. Differences in the previous tapping history of the six areas may possibly account for this, for the position of the tapping cuts in relation to the junction of the virgin and renewed bark of previous tapping panels varies in each experiment.

TABLE XIV. *Tapping Experiments Nos. 21 to 26*

Results for the first year, November 1938 to October 1939

Yield of System 1 in lb. per acre and of systems 2, 3 and 4 as a percentage of system 1

Experiment No.:-	22	26	24	25	21	23	Mean
Locality	Selangor	Johore	Selangor	Johore	Selangor	Selangor	
Tapping Systems							
1. A.D. without rest C/2,d/2,100%	320	344	380	369	378	461	375
2. A.D., A.B.C. Four months tapping, two months rest C/2,d/2,4m/6,67%	68	81	71	74	82	60	72
3. A.D., A.B.C. Eight months Tapping, four months rest C/2,d/2,8m/12,67%	67	77	75	76	105	58	76
4. A.D., A.B.C. Twelve months tapping, six months rest C/2,d/2,12m/18,67%	71	80	75	75	90	58	75
No. of tappings	158	163	174	164	164	175	

These differences in tapping history have in all probability also affected the comparative yields of the periodic systems in which the tapping cuts were opened at 36-37 inches.

The general conclusion to be drawn from these six experiments is that a reduction of tapping intensity from 100 per cent to 67 per cent by changing from continuous to periodic alternate-daily tapping is accompanied during the first year by a loss of from 25-30 per cent crop without any adequate saving in tapping costs. The results are not dissimilar from those obtained in the R.R.I. experiment on Seventh Mile Estate.

B. *Comparison of Tapping Systems with and without Manuring. Tapping Experiment No. 36. Estate F*

The first year of comparative tapping in this experiment on seedling rubber planted in 1925 was completed on 30th

September 1939. The first application of fertilisers was given on 1st October 1938 but no differences in the growth or yield of the manured and unmanured plots had been revealed by the end of the year. The tapping systems employed and the yields for the first year of the manured and unmanured plots combined are presented in Table XV.

TABLE XV. *Tapping Experiment No. 36*

Results for the first year October 1938 to September 1939 inclusive
Total Dry Rubber (No. 1 sheet plus lower grades)

Tapping Systems:—	1. A.D. without rest	2. A.D., A.B.C. six months tapping, three months rest
	V/2,d/2,100%	V/2,d/2,6m/9,67%
Yield in pounds per acre ...	857	—
Adjusted relative yield ...	100.0	77.1
Tapping cost in cents per pound	2.89	—
Adjusted relative cost ...	100.0	86.5
Mean monthly d.r.c. ...	35.1	36.7
Girth increment (cm./ann.) at 55"	2.4	2.8

The relative yields are similar to those recorded in Experiments Nos. 21 to 26; the tapping intensities of the two systems being more or less reflected in the crop obtained. Although some benefit from rest is indicated, the slight reduction in tapping cost could not under normal conditions compensate for the loss of over 20 per cent of crop unless other considerations dictate a reduction in tapping intensity. The better growth-rate and the slightly higher d.r.c. of latex recorded on the milder-tapped trees may however augur a future improvement in yield of the latter.

C. *Full-spiral, double-cut (half-spiral) and normal single-cut tapping.*
Tapping Experiment No. 47. (R.R.I. Experiment Station, Field 6)

The results of the small-scale experiment set up in August 1935 on seedling trees in the plot-border rows of Field 6 at the Experiment Station are summarized in Table XVI.

All tapping heights are measured from ground level to the lowest point of the tapping cut. Alternate trees in System 4 (control) were opened at heights of 20 inches and 40 inches to

correspond with the mean height of tapping in Systems 1, 2 and 3.

In order to maintain bark consumption on the different systems at the same relative rates the amounts of bark to be used were clearly marked on the panels at intervals of three months. It has not however, been found possible in practice to prevent a slight over-consumption of bark in Systems 1, 2 and 3. Since there has also been a small under-consumption of bark in System 4 the mean heights of tapping are no longer quite equal.

In August 1939 the low cuts in Systems 1 and 2, originally opened at 20 inches, reached ground level and new cuts were opened on the same panel at 40 inches. The drop in the relative yields of these two systems may be attributed mainly to low yields obtained from newly-opened cuts. Full-spiral tapping, System 3, continues to give satisfactory results.

TABLE XVI. *Tapping Experiment No. 47. R.R.I. Experiment Station
Field 6*

Results August 1935 to December 1939

Tapping Systems	Yield as percentage of Control		Height of Tapping Cuts (inches)	
	Aug. 1935 to Dec. 1938	1939	Aug. 1935	Jan. 1939 (Approx.)
1. A.D. on two half-circ. cuts. Three months tapping and three months rest. 2S/2,d/2,3m/6,100%	97	89	40 and 20	6 and 26
2. Fourth-daily on two half-circumference cuts. No rest. 2S/2,d/4,100%	113	99	40 and 20	6 and 26
3. Full-spiral fourth-daily. No rest. S/1,d/4,100%	126	119	30	14
4. A.D. on half-circumference cuts. No rest. S/2,d/2,100%	100	100	40 and 20	10 and 30

In 1939 the trees in System 4 yielded 11.8 lb. of dry rubber per tree.

D. *Influence of Height of Tapping on Yield of Seedling Trees.**Tapping Experiment No. 43 (R.R.I.E.S. Field 25 V)*

The results for the first period, 18 months, in the experiment set up in Field 25(V) at the Experiment Station to compare the yields of seedling trees at different heights of tapping are presented in Table XVII.

The mean height of tapping has been calculated from bark consumption, measured in October 1939. The results show generally that there is an average decline in yield of just over $1\frac{1}{2}$ per cent for every inch the tapping cut is raised above the lowest tapping level of approximately 15 inches. It is interesting to compare this figure with the results of the similar experiment on budded trees in Field 22 A (vide Table XXXII).

TABLE XVII. *Tapping Experiment No. 43. Comparison of Yields of Seedling Trees tapped at different Heights (R.R.I. Experiment Station Field 25 V)*

Total Dry Rubber (Cup-lump) from 244 tappings (July 1938 to December 1939)

Treatment	Tapping Height		Yield lb. per tree per annum	Relative yield at different heights compared with treatment				Percentage decline in yield between one tapping height and next below	
	July 1938	Mean 1939		(1)	(2)	(3)	(4)	per inch	per cm.
1	20 in.	14.6 in.							
	51 cm.	37 cm.	6.6	100	120	140	169		
2	30 in.	24.4 in.						1.73	0.68
	76 cm.	62 cm.	5.5	83	100	117	141		
3	40 in.	34.2 in.						1.53	0.60
	102 cm.	87 cm.	4.7	71	85	100	120		
4	50 in.	44.9 in.						1.59	0.63
	127 cm.	114 cm.	3.9	59	71	83	100		

Tapping system. A.D. without rest (S/2,d/2,100%).

Field 25(V)—planted December 1931 with a mixture of clonal seed from various sources (F.B. clones, G.I, S.R.9, Sabrang 24, Avros clones etc.). Age at opening 6 years; average age during above period = $7\frac{1}{4}$ years.

(2) TAPPING EXPERIMENTS ON BUDDED TREES

A. *Tapping of Mature Budded Trees. Tapping Experiment No. 37 (Pilmoor Estate)*

The original budgrafts of the Pilmoor clones have been tapped on renewed bark since the middle of 1937. By December 1939 the tapping cuts had reached a height of approximately 12 inches above the union. Bark consumption was slightly over three-quarters-of-an-inch per month on alternate-daily tapping. The summarised data on girth, yield and d.r.c. of latex of the two principal clones, B. 84 and D. 65, are given in Table XVIII.

TABLE XVIII. *Tapping Experiment No. 37, Tapping of Mature Budded Trees—Pilmoor Clones*

Total Dry Rubber (No. 1 sheet and lower grades)

Yield in lb. per tree per annum

Clone	B. 84					D. 65				
Year	1935	1936	1937	1938	1939	1935	1936	1937	1938	1939
Year of life	11th	12th	13th	14th	15th	11th	12th	13th	14th	15th
GIRTH in inches at 40 in. from union	37.6	38.9	40.2	41.8	43.1	37.3	39.2	39.8	41.4	42.4
YIELD in pounds per tree per year	19.2	21.5	17.7	19.4	21.1	23.2	23.0	17.6	21.2	22.0
Mean dry rubber content of latex per cent	38.2	37.8	39.6	37.2	36.8	31.0	36.4	34.3	29.0	26.7

Tapping System: Alternate-daily on a half-circumference without rest. (S/2,d/2,100%).

Both clones show a small increase on the yield of 1938. The weather continued to be exceptionally dry, a rainfall of only 80 inches being recorded which is approximately 20 inches below the normal average for this estate. Secondary "wintering" occurred in July, the month of lowest rainfall when there were only three rainy days with a total of 0.63 inch of rain followed by a long spell of 26 dry days. This caused a partial defoliation of the trees of clone B. 84 and complete defoliation of clone D. 65, resulting in a drop in the yields of both clones. The exceptionally dry weather may be partly responsible for the low rate of increase in yield and girth.

TABLE XIX. *Tapping Experiments Nos. 1 to 5.*
Comparison of Tapping System on Budded Trees

Total dry rubber

Experiment No:—	No. 1			No. 2		
Locality:—	Estate J (N.S.)			Estate K (Johore)		
Clone:—	P.B.25			Avros 49		
Age first tapped:— (from budding)	5 years			6 years		
Uniformity trial	(one year)			(one year)		
Yield, lb. per acre/annum	578			517		
(No. of tappings) ...	(171)			(144)		
Comparative tapping *	4 years			3 years		
(a) prior to 1939	System 1	System 2	System 3	System 1	System 2	System 3
Mean annual yield (lb./acre) ...	1004	686	682	755	590	538
Average tappings per year ...	(174)	(116)	(116)	(146)	(98)	(98)
Relative yield ...	100	68	68	100	78	71
(b) 1939 †						
Yield, lb. per acre ...	1116	728	775	1131	802	770
(No. of tappings) ...	(173)	(115)	(115)	(154)	(102)	(102)
Relative yield ...	100	65	69	100	71	68
Approx. tapping height in inches ...	30-20	2-0 40-35	36-32	37-27	13-8 40-37	9-6 40-34
Age (years) ...	11			11		

* The three tapping systems used are—

- (1) Alternate-daily on a half-circumference without rest ...
- (2) A.D., A.B.C. on a half-circumference. Six months tapping ...
- (3) Third-daily on a half-circumference without rest ...

† Records are summarised in calendar years for Experiments 2, 3 and 4 (1939),

*Experiments in monoclonal fields of five clones**(18-plot Experiments: Estates J & K)**(No. 1 sheet plus lower grades)*

No. 3			No. 4			No. 5		
Estate K (Johore)			Estate K (Johore)			Estate J (N.S.)		
Avros 50			Avros 152			S.R.9		
5 years			6 years			6 years		
(one year)			(one year)			(two years)		
464			392			521		
(149)			(144)			(173)		
3 years			3 years			2 years		
System 1	System 2	System 3	System 1	System 2	System 3	System 1	System 2	System 3
732	512	476	622	432	420	665	456	482
(149)	(99)	(99)	(147)	(99)	(99)	(172)	(114)	(114)
100	70	68	100	69	68	100	69	72
984	668	643	1038	661	700	589	458	397
(157)	(106)	(106)	(163)	(108)	(108)	(172)	(115)	(115)
100	68	65	100	64	67	100	78	67
37-27	13-8 40-37	9-6 40-34	37-27	13-8 40-37	9-6 40-34	40-30	12-5	7-0 40-39
10			11			11		

... and three months rest ... (S/2,d/2,100%)
 ... (S/2,d/2,6m/9,67%)
 ... (S/2,d/3,67%)

} All tapping on virgin bark.

but from October to September inclusive in Experiments 1 and 5 (1938/39).

The dry rubber content of the latex of both clones has continued to decrease since 1937 when the present tapping panel was opened on renewed bark.

The results of tapping clone B. 84 on two systems, alternate-daily (S/2,d/2,100%) and daily alternate-monthly (S/2,d/1,m/2,100%), were described in detail in the Annual Report for 1938 (pages 77-78). In 1939 the girth and yield of the trees tapped on the daily periodic system as percentages of those tapped on continuous alternate-daily were 92 per cent and 91 per cent respectively.

B. *Comparison of Tapping Systems on Various Clones*

(a) *Tapping Experiments Nos. 1 to 5. (Estate J & K) 18-plot experiments in monoclonal fields*

A summary of the yields of the five experiments up to the end of 1938 and for 1939 are presented in Table XIX. The data cover a period of five years tapping on three systems in Experiment 1, four years in Experiments 2, 3 and 4 and three years in Experiment 5.

Since these experiments are set up in different localities under widely different conditions the yields of the five clones are not directly comparable with each other.

The yields of clones P.B. 25 and S.R. 9 on Estate J are 20 and 15 per cent lower respectively than in the previous year. This decline in yield which has affected all three tapping systems almost equally can probably be attributed to the exceptionally dry weather of 1938 and 1939.

New tapping panels were opened in September 1938 in the control plots (S/2,d/2,100%) in the three experiments on the Avros clones on Estate K and an excellent increase in yield can be recorded in each case.

As in previous years the yields from the three tapping systems are almost exactly proportional to the tapping intensity, and there is no sign yet of any improvement in yield in the two lighter tapping systems.

A more careful re-count of dry trees in Experiment No. 1 on P.B. 25 between August and October 1939 indicated that the figures quoted in the last Annual Report were probably too high. The total number of dry trees, including those dry on account of causes other than brown bast, was insignificant on all three tapping systems, the percentage being 3.0, 0.7 and 1.9 in tapping systems 1, 2 and 3 respectively.

Girth measurements taken on a representative sample of trees of all five experiments show a slight retardation in growth on

100 per cent tapping compared with the two lighter 67 per cent systems. In 1939 the mean growth rates in cm. per annum of all five experiments combined were: 3.05 on system (1), 3.61 on system (2) and 3.44 on system (3). (General mean=3.37 : s.e. ± 0.241).

This slightly greater retardation in the rate of growth of the trees tapped without rest periods on half-circumference alternate-daily is not yet important, but if it should become more marked in the future it may be desirable to adopt a lighter tapping system.

It is, however, clear that under the conditions of these experiments vigorously growing young buddings can be tapped on a system of 100 per cent intensity without showing any ill effects and that it has not been profitable to tap them at an intensity as low as 67 per cent.

(b) *Tapping Experiments 6 & 7 (Estate L). 22-plot experiments in monoclonal fields*

As an extension of the series of tapping experiments on monoclonal fields of young rubber, two new experiments were initiated on Estate L (Johore). An improved factorial lay-out comparing five tapping systems was adopted in place of the old 18-plot lay-out with only three systems, which is open to technical criticisms. One experiment (No. 6) was set up in a contour-planted field of B.D. 5 and the other (No. 7) in a gently undulating field of Tj. 1.

A preliminary uniformity trial on the standard system (S/2,d/2,100%) was carried out from December 1938 to June 1939. Previously, the B.D. 5 trees had been in commercial tapping for about six months and the Tj. 1 trees for about a year on normal alternate-daily tapping on half-circumference. The approximate ages of the buddings of the Clones B.D. 5 and Tjirandji 1 at the commencement of tapping were 7 and $5\frac{1}{2}$ years, and the opening heights 22 and 40 inches from the union, respectively.

The tapping systems compared are defined and the results for the first few months of the two experiments are summarised in Table XX. Records for the period July to September 1939 have not been reported, this being regarded as an interim period before the periodic systems had got into full regime. On system E the former half-cuts were extended upwards to full-spirals during July. The first two plots of system B came back into tapping on October 1st after rest; the first change of panel also dates from October 1st in system D, and it is convenient to regard this as the commencement proper of comparative tapping.

TABLE XX. *Tapping Experiments Nos. 6 and 7. Twenty-two-plot Experiments on Budded Trees (Estate L.) Yields for October—December 1939 (Total dry rubber including scrap)*

Experiment No.				6				7			
Clone				B.D. 5				Tj. 1			
Age first tapped				7 years				5½ years			
Age on 1st October 1939				8½ years				7¼ years			
No. of tapplings in System A				46				37			
Tapping Systems				Relative Yields (Adjusted)	Percentage Lower Grades	Mean d.r.c. per cent	Relative Tapping Costs (Adjusted)	Relative Yields (Adjusted)	Percentage Lower Grades	Mean d.r.c. per cent	Relative Tapping Costs (Adjusted)
A. A.D. on half-circumference without rest S/2,d/2,100%				100	10.7	39.4	100	100	7.4	37.1	100
B. A.D., A.B.C. six months tapping, three months rest S/2,d/2,6m/9,67%				70	9.9	39.8	95	67	7.7	38.5	100
C. D.A.M. on half-circumference S/2,d/1,m/2,100%				94	9.6	36.9	106	85	6.2	35.0	118
D. A.D. on half-circumference without rest. Tapping panel changed to opposite side of tree every seven months S/2,d/2,(2 × 7m/14)100%				99	9.7	37.9	101	112	6.2	36.8	89
E. Full-Spiral fourth-daily S/1,d/4,100%				132	11.0	37.0	54	116	* 8.6	34.2	62

The trees of B.D. 5 (Experiment 6) tapped on a full-spiral show a considerable increase in yield and a big reduction in the cost of tapping compared with the control.

The trees of Tj. 1 (Experiment 7) tapped on a full-spiral showed a comparatively small increase in yield though there is a considerable saving in the cost of tapping. No allowance however has been made for the extra cost of afternoon collections. These were necessary on about fourteen out of the eighteen tapping days in each of the E plots; without these extra collections the percentage of lower grades would certainly have been considerably higher.

(c) *Tapping Experiment No. 41 (R.R.I.E.S. Field 5). Comparison of tapping systems; 100 per cent. continuous and 67 per cent. periodic, both alternate-daily, and 100 per cent. daily periodic on nine clones.*

The results of the second year of comparative tapping in the Field 5 clone trial at the Experiment Station differ little from those published last year; the results for both years are given in Table XXI.

TABLE XXI. *Tapping Experiment No. 41 (R.R.I. Experiment Station Field 5) on nine clones*

Yield of System 1 in lb. per tree per annum and yields and costs of Tapping of Systems 2 and 3 as a percentage of system 1

Clones		System 1. A.D. on half- circumference without rest S/2,d/2,100%		System 2. Daily alter- nate-monthly on half- circumference without rest S/2,d/1,m/2,100%				System 3. A.D., A.B.C. on half-circumference 6 months tapping 3 months rest S/2,d/2,6m/9,67%			
		Yield lb. per tree per annum		Yield as percentage of System 1		Cost as percentage of System 1		Yield as percentage of System 1		Cost as percentage of System 1	
		1938	1939	1938	1939	1938	1939	1938	1939	1938	1939
Avros	49	8.9	9.8	106	99	94	101	71	71	94	94
"	50	8.8	10.4	100	89	100	112	62	63	108	106
"	152	5.9	6.5	123	125	81	80	78	82	85	81
B.D.	5	6.6	7.3	82	93	122	108	70	71	95	94
A.	44	9.5	9.8	105	104	95	96	74	74	90	90
B.	84	9.2	10.2	92	101	109	99	76	80	88	83
P.B.	23	8.8	10.1	106	107	94	93	84	84	79	79
P.B.	186	9.5	11.2	85	75	118	133	65	59	103	113
Tj.	1	12.2	13.9	97	94	103	106	67	69	99	97
Mean		8.8	9.9	100	97	100	103	72	72	94	93

Recording in this experiment is by latex collection, with ordinary preparation of sheet and separate weighing of lower grade rubber in system 1 and by cup-coagulation of the total crop in systems 2 and 3. The latter method gives relatively higher figures owing to incomplete drying of cup lumps before weighing. The figures presented in Table XXI have been corrected to true dry weights and the relative yields on the three systems now come into line with those from other tapping experiments.

Considering the mean yield of all clones, yield on the d.a.m. system 2 is almost the same as on the a.d. system 1 but it will be seen that clones differ in their response to these two systems. For example, Clone Avros 152 gives an increase in yield of about 24 per cent when tapped daily in alternate months, a result which has been repeated elsewhere, whilst Clone P.B. 186 shows a loss of about 20 per cent when tapped on that system.

As in Experiments Nos. 1 to 5 (Table XIX), response to periods of rest in system 3 has been very small and there has been a mean loss in crop of 28 per cent for all clones combined.

(d) *Tapping Experiment No. 42, (R.R.I.E.S., Field 21). Comparison of full-spiral, daily periodic and normal alternate-daily tapping on seven clones*

The results of the first two years of this experiment are presented in Table XXII. Recording of yields was by cup coagulation and weighing of cup-lumps. The figures have been corrected to allow for the varying moisture content of the different sizes of cup lump which accounts for the small discrepancies between the 1938 yields shown here and those given in the Annual Report for 1938.

A wide variation in the response of the seven clones to the different systems of tapping is again marked. The clones which have responded best to full-spiral tapping are Avros 50, Avros 71, B.D. 10 and Ct. 88; the yield of Ct. 88 has been almost doubled on this system. Daily periodic tapping appears to suit Avros 256 and Ct. 88 better than the other clones.

Up to the present the two sets of trees tapped on the daily periodic systems 2 and 3, have given almost identical yields. From the beginning of 1940 system 3 will be modified to "economic periods." Economic periods are based on the daily yield curves from a consecutive period of twelve months in 1938-39. Plotting of the mean serial daily yields for these twelve months showed that optimum periods of tapping and rest would not be the same for all clones. Monthly periods appeared too long for Ct. 88 and too short for the remaining clones, markedly so for Avros 256. Periods in system 3 will accordingly be modified as follows:

Ct. 88 ... 24-day periods = S/2,d/1,24d/48,100%
 Avros 50, 71, B.D. 10,
 S.R. 9 and Tj. 16 ... 36 ,, ,, = S/2,d/1,36d/72,100%
 Avros 256 ... 48 ,, ,, = S/2,d/1,48d/96,100%

Monthly periods will be retained in system 2 for all clones; but arbitrary months of 30 days will henceforth be used instead of calendar months—the system being strictly S/2,d/1,30d/60,100% in place of S/2,d/1,m/2,100%. Since all periods are multiples of six, changes from tapping to rest and *vice versa* will not occur more frequently than at six-day intervals, and the supervision of tapping will be simplified.

TABLE XXII. *Tapping Experiment No. 42. (R.R.I.E.S. Field 21) Yields for 1938 and 1939 of System 1 in lb. per tree per annum and of Systems 2, 3 and 4 as a percentage of System 1*

Clones	Yields					
	System 1. A.D. on half-circ. without rest S/2,d/2,100%		Systems 2 & 3. Daily alternate-monthly on half-circ. without rest S/2,d/1,m/2,100%		System 4. Full-spiral fourth-daily without rest S/1,d/4,100%	
	1938	1939	1938	1939	1938	1939
Avros 50	7.2	9.6	111	111	135	142
„ 71	8.4	9.7	97	102	118	145
„ 256	3.8	5.6	129	126	67	115
B.D. 10	7.8	10.3	111	117	128	142
Ct. 88	8.5	10.3	112	126	194	185
S.R. 9	5.8	6.8	100	96	97	107
Tj. 16	9.4	10.5	103	109	100	122
Mean	7.3	9.0	109	112	120	139

The trees in this experiment were budded in September 1931

(e) *Tapping Experiment No. 33 (Prang Besar Estate). Comparison of full-spiral and other tapping systems on Prang Besar Clones and S.R.9.*

The tapping experiment set up on Prang Besar Estate (referred to as “Estate II, Selangor” in the Annual Report for 1938) started on January 1st. The site is a clone trial laid out by Dr. R. J. Chittenden in 1931 in monoclonal tasks of 377 planting points in Block 15 of the Estate. The arrangement of the clone

trial is in six randomised blocks distributed over three hills of a steep, contour-planted area of about 90 acres.

A factorial lay-out, five clones $\times$ five systems of tapping, was adopted for the superimposed tapping experiment. Duplicate A and B plots of each clone were provided on system 5, daily alternate-monthly tapping, to eliminate month-to-month seasonal effects.

TABLE XXIII. *Tapping Experiment No. 33. (Prang Besar Estate)*

*Yields of all Clones combined (P.B. 23, 86, 183, 186 and S.R. 9)
during first year of Tapping (1939)*

Tapping Systems	Total dry rubber, No. 1 sheet and lower grades			
	Yield per acre lb.	Lower Grades per cent	Adjusted relative yields per cent	Adjusted cost of tapping per cent
1. A.D. on half-circumference without rest ... S/2,d/2,100%	713	11.1	100	100
2. A.D. on third-circumference without rest ... S/3,d/2,67%	521	11.5	74	135
3. Third-daily on-half-circ. S/2,d/3,67%	602	11.0	78	85
4. Full-spiral fourth-daily ... S/1,d/4,100%	798	19.1	107	67
5. D.A.M. on half-circ. ... S/2,d/1,m/2,100%	716	9.2	93	107

Trees which had attained a girth of 20 inches at 40 inches from the union were opened at 40 inches towards the end of November 1938, at an age of just over 7 years, and tapped on the standard system for a uniformity trial of one month during December. Comparative tapping on the five chosen systems began early in January 1939.

When the experiment was laid out the mean percentage of tappable trees in the plots allocated to each of the five systems were: (1) 71, (2) 66, (3) 71, (4) 73 and (5) 70. Girth measurements in May 1939 confirmed the even distribution of growth, for the average girths of trees in the plots tapped on each of the five systems fell within 60-62 cm. (at 55 inches from the union).

In accordance with estate practice all additional trees estimated to reach tappable standard by October were brought into tapping on July 1st. At the same time the size of plots of system 4, on full-spiral tapping, was reduced to 70 per cent by cutting off 30 per cent of their former area (*i.e.* 113 planting points out of the total of 377 per plot), to approximate to the correct task ratio for this system in practice.

Records of total yield per acre on each system, all clones combined, are presented in Table XXIII.

Systems 2 and 3 both show a positive response to the lower intensity of tapping, but the cost of tapping on system 2 is very high.

System 4 shows only a small increase in yield compared with system 1, but there is considerable economy in cost of tapping. The proportion of lower grade rubber on system 4 is unfortunately very high.

Since only one plot of each clone is tapped on systems 1 to 4 a valid estimate of the interactions between clones and tapping systems cannot be made.

The mean yields and other data for each of the five clones, all tapping systems combined, are given in Table XXIV.

TABLE XXIV. *Tapping Experiment No. 33. (Prang Besar Estate)*
Yields of Clones, all Tapping Systems combined, for First Year of Tapping (1939)

Clones:—		P.B. 23	P.B. 86	P.B. 183	P.B. 186	S.R. 9
Girth in cm. at 55 inches (May 1939)	...	63	61	63	64	58
Tappable Trees*	Nov. '38	72	71	71	77	59
as percentage of total trees	July '39	74	75	74	80	66
Yield per acre†						
total dry rubber in lb. per annum	...	660	996	523	730	481
percentage of lower grades		15	10	15	10	12

* Tappable standard: 20 inches girth at 40 inches from union.

† Average intensity of the combined tapping systems was 89 per cent. The above yields are for the eighth year of life.

In growth, the most vigorous clone is P.B. 186, while S.R. 9 is the most backward. In yield P.B. 86 is outstanding, P.B. 23

comes next, followed by P.B. 186, while P.B. 183 and S.R. 9 lag behind. The yield of P.B. 86 is most satisfactory, almost 1,000 lb. per acre during the eighth year of life at an average tapping intensity of 87 per cent. The calculated yield on 100 per cent tapping is over 10 lb. per tree.

(f) *Single-task Tapping Experiments on Monoclone Areas*

Three experiments of a new design have been set up on monoclone budded areas. Each experiment comprises from ten to fifteen tapping systems spread over 600-700 trees in an ordinary commercial field. A single tapper is employed to tap the experimental area, his daily task consisting of 200-225 trees on full, half, third and quarter cuts (single or double). Continuous and periodic systems with tapping at various frequencies ranging from daily to fourth-daily are compared and change-over tapping and systems with annual rests during the wintering period may also be included. A careful system of numbering and lettering trees in the field ensures that they are tapped on the correct days.

Each tree is a single "plot." There are two, three or four replicate series of plots of each system, according to frequency of tapping and periodicity, all series being represented in each of fifteen to eighteen randomised blocks. Prior to randomisation, the trees are grouped into blocks by girth classes, regardless of their position in the field, and tapped on the standard system (S/2,d/2,100%) to obtain preliminary yields, individual yields being recorded by cup coagulation as in experimental tapping.

Among advantages claimed for this type of experiment are elimination of variations in tapping skill, reduction of the experimental area to six to ten acres and the number and wide range of tapping systems compared. Trees tapped on any one system are scattered throughout the site and, since they do not exceed 40 to 70 in number, the risk of extensive damage due to tapping trees on drastic or experimental systems is minimised. The experiment is so arranged that one tree on each system is tapped daily in each block. By this balanced lay-out errors due to seasonal effects are eliminated and results can be compared over any period.

Interference with estate tapping routine is negligible, for a special conductor is provided to make out daily tapping schedules, supervise the tapper in the field, weigh produce and keep monthly records.

A drawback to single-task experiments is the possible loss of several "plots" of the same system through disease, wind damage and other causes. However, simple approximations for the missing plot yields can be used in the running summaries, and final evaluation of results is not expected to be unduly complicated.

(i) *Tapping Experiment No. 34, Clone Bodjong Data 5.*
(Belata River Estate, Selangor)

This experiment was set up on ten acres of a steep contour-planted area of $7\frac{1}{2}$ years-old budgrafts of B.D. 5 on friable yellow loam soil of quartzite origin. The trees, planted in 1930 on land

TABLE XXV. *Tapping Experiment No. 34, Single Task Experiment on B.D.5 (Belata River Estate)*

Results for first half year July—December 1939. Adjusted Yield as a percentage of System 2, tapped alternate-daily on a half-spiral cut

Tapping Systems	Yield
1. D.A.M on half-circumference S/2,d/1,m/2,100% ...	109
2. A.D. on half-circumference S/2,d/2,100%	100
3. A.D. on third-circumference S/3,d/2,67%	80
4. A.D. on half-circumference. Two months rest during wintering S/2,d/2,100% $\times$ 10m/12	108
5. A.D., A.B.C. on half-circumference. Six months tapping three months rest S/2,d/2,6m/9,67%	74
6. Third-daily on half-circumference S/2,d/3,67% ...	88
7. Full-spiral, third-daily S/1,d/3,133%	169
8. Full-spiral, third-daily, A.B.C.D. Three months tapping, one month rest S/1,d/3,3m/4,100%	131
9. Full-spiral, fourth-daily, S/1,d/4,100%	161
10. Full-spiral, fourth-daily, two months rest during wintering S/1,d/4,100% $\times$ 10m/12	163
11. A.D. on half-circumference. Change-over every seven months S/2,d/2,(2 $\times$ 7m/14)100%	99

The mean yield per tree for System 2 during this period was 2.4 lb. System 4 and 10. No rest was given during this period.

System 5. One-third of the trees were rested from July to September. The remainder have not yet been tapped after a period of rest.

System 11. The first change of tapping panel took place on 1st December when a new cut was opened 20 inches above the old cut on the opposite side of the tree.

cleared from virgin jungle and budded in 1931-32, were backward for their age in spite of four applications of manure. The original planting distance was 19 feet $\times$ 19 feet, giving about 121 points to the acre. The average stand over the 166-acres field where the experiment is situated was 111 trees per acre in April 1939.

All trees with a girth of 18 inches or over at 40 inches from the union were marked for tapping at 25 inches above the union; even on this reduced standard a tappable percentage of only 68 per cent was reached.

Girth measurements in November 1938 showed that the average girths of the trees tapped on each system varied only within the limits 54-55 cms. at 55 inches and 64-66 cms. at 3 feet above union. The experimental lay-out comprised nineteen blocks, each block containing thirty-four trees tapped on eleven different tapping systems. Preliminary yields were taken during one month (on S/2,d/2,100%) during May 1939. Comparative tapping started early in June, but the first month is regarded as a transition period and the yields for June 1939 have been excluded from the records summarised in Table XXV, which cover the last six months of 1939.

The total number of tappable trees at the commencement of the experiment was 646 of which sixteen had been lost or were out of tapping by the end of the year. The tapper's daily task consisted initially of 228 trees.

Although the period covered is short, several points of interest may be noted.

Big increases in yield from the systems with a full-spiral cut (7, 8, 9 and 10) have been recorded, but it appears that system 7, at 133 per cent tapping intensity, is likely to prove too severe. Systems 3, 5 and 6 all show a positive response to a reduction in tapping intensity.

(ii) *Tapping Experiment No. 46, Clone B.D. 5.*
(R.R.I.E.S. Field 19A)

This experiment is similar in general design to Experiment No. 34. Thirteen different tapping systems are being compared, arranged in 18 blocks of 36 trees. The average girth of the trees tapped on each system varied only within the limits of 53-54 cm. at 50 inches above the union when measured in May 1939 and within 66-67 cm. at 36 inches above the union when measured in September 1939.

The trees were about 8½ years old when the experiment started. The site is undulating, about half being contour-planted and half square-planted and the soil is a sandy loam, cleared from virgin jungle before planting. At the time of budding the density of

planting was 180 trees per acre and the area was thinned in September 1937 to 140 trees to the acre. Growth is satisfactory for B.D. 5 and about 127 trees per acre were in tapping by the end of 1938, the larger trees having then been tapped for three years and the smaller for shorter periods.

TABLE XXVI. *Tapping Experiment No. 46, Single task Experiment on B.D.5 (R.R.I.E.S. Field 19A)*

Results for the first quarter October—December 1939. The adjusted Yield as a percentage of System 2, tapped alternate-daily on a half-spiral cut

Tapping Systems	Yield
1. D.A.M. on half-circumference S/2,d/1,m/2,100% ...	97
2. A.D. on half-circumference S/2,d/2,100% ...	100
3. A.D. on half-circumference. Opposite panels tapped alternately S/2,d/2(2 × 2d/4),100% ...	108
4. A.D. on third-circumference S/3,d/2,67% ...	73
5. A.D. on two quarter-cuts 2S/4,d/2,100% ...	97
6. A.D. on half-circumference with two months rest during wintering S/2,d/2,100% × 10m/12 ...	96
7. A.D. A.B.C. on half-circumference. Six months tapping three months rest S/2,d/2,6m/9,67% ...	70
8. Daily A.B.C. on half-circumference. One month's tapping, half a month rest S/2,d/1,m/1.5,133% ...	130
9. Third-daily on a half-circumference S/2,d/3,67% ...	68
10. Full-spiral, third-daily S/1,d/3,133% ...	137
11. Full-spiral, third-daily, A.B.C.D. Three months tapping, one month rest S/1,d/3,3m/4,100% ...	102
12. Full-spiral, fourth-daily S/1,d/4,100% ...	135
13. Full-spiral, fourth-daily with two months rest during wintering S/1,d/4,100% × 10m/12 ...	123

The mean yield of the trees in system 2 during this period was 2.0 lb.

System 7. One section was rested from August to October; the other

two sections have not been tapped after a period of rest.

The experiment was preceded by a uniformity trial on S/2,d/2,100% for five months from February-June 1939. The trees were marked out during the early part of July, and tapping on new cuts (in systems requiring a change of cut) started on July 15th so as to allow a "flying start" of two weeks before the commencement of experimental tapping on August 1st. The total number of trees in tapping was 648 and the tapper's daily task 252 trees. Yields for the induction period, August and September, have been excluded from Table XXVI, which summarises the results for three months, October to December 1939.

The period of three months is too short to justify more than a brief reference to the results. The yields from the full-spiral systems (systems 10 to 13) are considerably lower than those obtained in Experiment No. 34 on the same clone. The yield on system 8 is about the same as that on system 12 and it would seem that increasing the tapping intensity of the former system by 33 per cent is not justified by the results.

(iii) *Tapping Experiment No. 8, Clone Tjirandji 1 (Estate N)*

The third experiment in this series was set up on Estate N in Negri Sembilan towards the middle of the year. The selected site is part of a 700-acres block of Tj. 1 on flat to gently undulating clay loam, planted from virgin jungle (18 feet $\times$ 12 feet) in 1930 and budded in May and June 1932. Normal commercial tapping had commenced in July 1938, at the age of six years, and had been in progress for twelve months when the experiment started. Some 85 trees per acre were being tapped out of a total stand of 160 trees per acre.

The experiment is arranged in fifteen blocks of 38 trees tapped on fourteen systems. The September measurements showed that the average girth of the trees tapped on each system varied within the narrow limits of 56-57 cm. The experiment extends over some seven acres and comprises a total of 570 trees. The tapper's daily task is 225 trees. Preliminary yields were recorded for a period of six weeks (on S/2,d/2,100%) starting on 1st September 1939. A short induction period followed, certain trees being rested from October 15th in order to begin the experiment with a "flying start" on November 1st. Analysis of yield-records for the half-month induction-period indicated a standard error of about 10 per cent per treatment mean.

The tapping systems compared are the same as those in Experiment No. 46 except that treatment 8, S/2,d/1,1m/1.5,133% has been omitted and the change over system S/2,d/2,2 $\times$ 7m/14,100% used in Experiment No. 34 has been included. One further system

not used in either of the two older experiments is also being tried in this experiment namely, daily A.B.C. on two $\frac{1}{4}$ -cuts tapped for one month and rested for half a month, 2S/4,d/1,m/1.5,133%.

It is too soon to draw any conclusions from the results of the first two months of tapping which are not therefore included in this report.

(g) Tapping Experiment No. 48, (R.R.I.E.S. Field 5). Comparison of Double cut and single-cut tapping on budded trees.

The results of the small-scale experiment on nine clones in the plot border rows of Field 5 at the Experiment Station are summarised in Table XXVII below. The experiment was set up in May 1935 to compare double-cut tapping, with normal single-cut tapping on budded trees.

The control trees have been tapped throughout the whole period A.D. on a half-circumference cut without rest (S/2,d/2, 100%). The mean yield per tree in 1939 was 13.7 lb. The trees were divided into two equal groups in one of which the cuts were opened at 40 inches from the union and in the other at 20 inches.

In the double cut systems the cuts were also opened at 40 inches and 20 inches from the union. From May 1935 to April 1937 the trees were tapped on two half-circumference cuts alternate daily with three months tapping followed by three months rest (2S/2,d/2,3m/6,100%). The tapping system was then changed to the "double four" and the trees were tapped on the same two cuts every fourth day without rest (2S/2,d/4,100%).

Although the different clones show considerable variety in their response to double-cut systems of tapping, there has been throughout the duration of this experiment a steady decline in yield from these systems compared with the trees tapped on a single cut.

C. Slaughter-Tapping

Tapping Experiment No. 45 (R.R.I.E.S. Field 18C)

A slaughter-tapping experiment was set up towards the end of the year in Field 18 C at the Experiment Station on poorly-grown young trees situated mainly in a low-lying area scheduled to be replanted in 1940. The area, composed of buddings of sixteen clones with a few seedlings, was too small to allow full replication of the six selected tapping systems; but the lay-out is balanced in that one plot of each system is tapped on each

TABLE XXVII. *Tapping Experiment No. 48, Comparison of Tapping Systems (R.R.I.E.S. Field 5)*

Clone			Yield of double-cut trees as percentage of control (single-cut)				
			From 1935 to 1937 periodic (d/2,3m/6)		From 1937 to 1939 continuous (d/4, cont.)		
			1935-36 (May— Apr.)	1936-37 (May— Apr.)	1937 July— Dec.)	1938 (Jan.— Dec.)	1939 (Jan.— Dec.)
Avros	49	-	99	79	127	93	87
"	50	-	97	82	128	115	98
"	152	-	103	107	166	116	117
B.D.	5	-	77	83	122	109	99
Pil.A.	44	-	81	88	115	83	80
Pil.B.	84	-	91	95	127	115	99
P.B.	23	-	86	80	132	118	86
P.B.	186	-	82	84	124	83	75
Tj.	1	-	90	77	103	96	72
Mean (all clones)			90	84	127	103	90
Tapping Height (mean in ins.)							
Double-cut trees							
	High		38	34	30	26	22
	Low		18	14	10	6	2
Control							
	High		36½	29½	22½	36½	29½
	Low		16½	9½	3	15½	8½

day, thus eliminating from the comparative figures the effect of daily yield-fluctuations.

The experimental area is divided into ten half-task plots of about 75 trees each. Three tappers are employed daily, each of whom brings in the latex from two half-task plots tapped on different systems. The tappers change tasks in rotation at the end of each three-weekly period, to equalise errors due to tapping skill.

Normal alternate-daily 100 per cent tapping, system 6, is used as the control, the main comparison being between three continuous *full-spiral* systems at graded intensities, namely, system

5 at 133 per cent (third-daily), system 2 at 200 per cent (alternate-daily) and system 1 at 400 per cent (daily). In addition, there is a subsidiary comparison between full-spiral alternate-daily *continuous* tapping system 2 and two *periodic* systems of 200 per cent intensity operating over three-weekly periods; system 3 on full-spiral and system 4 on two half-spirals.

The experiment is planned to continue for about one year, though it is probable that the yields of the more drastic systems will become negligible before the end of this period. The trees were first opened at 20 inches in August 1938 and tapped for a year mainly on full-spiral systems (S/1,d/4,100% and S/1,d/5,80%), before the experiment was set up. Comparative tapping began

TABLE XXVIII. *Tapping Experiment No. 45. Slaughter-Tapping (R.R.I.E.S. Field 18C)*

Yields October—December 1939 expressed as percentage of the control

Tapping Systems	No. of plots	Adjusted relative yield in four three-weekly periods <i>Mean d.r.c. in italics</i>					Lower grades per cent	Brown Bast. Trees out of tapping after 3 months. per cent
		1st	2nd	3rd	4th	Total		
1. Full-spiral daily S/1,d/1,400% ...	1	207 27	110 23	101 24	96 23	128	19	10.4
2. Full-spiral A.D. S/1,d/2,200% ...	2	135 33	117 31	119 31	114 31	121	21	2.0
3. Full-spiral daily. Three weeks tapping, three weeks rest S/1,d/1,3w/6,200%	2	95 27	100 35	80 31	120 34	99	16	—
4. Two half-spiral cuts daily. Three weeks tapping, three weeks rest 2S/2,d/1,3w/6,200% ...	2	94 29	84 35	82 31	84 34	86	19	—
5. Full-spiral, third-daily. S/1,d/3,133% ...	3	102 35	98 34	117 34	123 33	110	18	—
6. Half-spiral A.D. No rest S/2,d/2,100% (control) ...	2	100 37	100 36	100 36	100 36	100	16	—

The mean yield per tree in the control plots for the three months was 2.5 lb.

on 9th October 1939, following five to six weeks preliminary period on the full-spiral fourth-daily system. Results for three months, covering the first four three-weekly periods, are summarised in Table XXVIII.

The results summarised in Table XXVIII demonstrate the relatively poor performance of all the intensive systems. The least drastic, full-spiral third-daily tapping (system 5), alone appears likely to give an economic increase in yield. The rapid falling-off in yield on full-spiral daily tapping (system 1) is also remarkable. The d.r.c. of the latex of trees tapped on this intensive system reached the extremely low level of 23 per cent within four to five weeks and over 10 per cent of the trees were out of tapping on account of brown bast at the end of three months. Comparing the three full-spiral systems, daily tapping at three times the cost (system 1) and alternate-daily tapping at a fifty per cent increase in cost (system 2) gave but slight increases on the yield obtained by third-daily tapping (system 5).

The control (system 6) had a slight advantage in height of cut, tapping being continued on the lower halves of the preliminary full-circumference cuts. A greater advantage in tapping height was obtained on system 4, where tapping continued on the lower halves of the cuts, and the opposite cuts were opened at the same level. No correction has been made for tapping height, but it might be justifiable to increase the relative yield on system 5 from 110 to 115 on this account.

It remains to be seen for how long the yields can be maintained on 133% tapping (full-spiral third-daily) but poor rubber of this type clearly cannot support more drastic systems, except perhaps for very short periods.

To what extent the results of this experiment are applicable to mature rubber is uncertain, but the general inference to be drawn would seem to be that better economic yields would be obtained by tapping for several months at a comparatively small increase in intensity, than by tapping for a short period at a very high intensity.

D. *Comparison of Tapping Systems with and without Manuring*

- (a) *Tapping Experiment No. 31 (Sepang Estate, Selangor). Comparison of three systems of tapping (from 67 to 100 per cent intensity) at three levels of manuring on polyclone planting of Prang Besar clones*

The results in the first year of tapping young mature bud-grafts in their tenth year at Sepang Estate, (referred to as

"Estate G" in the annual report of 1938), are summarised in Table XXIX.

TABLE XXIX. *Tapping Experiment No. 31. (Sepang Estate)*

Tapping at three levels of manuring on a polyclone planting of Prang Besar Clones

Result of the first year—(July 1938 to June 1939)

Tapping System	Adjusted relative yields per cent	Adjusted cost of tapping per cent	Mean d.r.c.	Girth increase cm.
1. A.D. on half-circumference. No rest. S/2,d/2,100%	100	100	36.8	2.55
2. A.D. A.B.C. on half-circumference. Six months tapping, three months rest. S/2,d/2,6m/9,67%	75.6	88	38.0	2.65
3. D.A.M. on $\frac{1}{2}$ cut S/2,d/1,m/2,100%	108.9	92	37.4	2.33

System 1 yielded at the rate of 1,145 lb. per acre total dry rubber.

Comparison of growth and yield on manured and unmanured plots does not yet reveal any fertilizer effects.

System 2 at a reduction in tapping intensity of 33 per cent shows a loss of crop of 24 per cent, which suggests that some small benefit is obtained from the resting periods.

System 3 gives a slightly higher yield than system 1, but it is probable that this is being obtained at the cost of a reduction in the rate of growth.

The daily yield curve on system 3 indicated that monthly tapping and resting periods were too long and that better results would be expected from three-weekly periods. System 3 was accordingly modified to S/2,d/1,3w/6,100%, in October 1939.

(b) *Tapping Experiment No. 32 (Sogomana Estate, Perak)*
Comparison of daily periodic and alternate-daily continuous tapping at four levels of manuring on a monoclonal field of B.D.5.

This experiment, laid out on a rather backward stand of nine-years-old budgrafts of B.D. 5 on an inland alluvial clay loam at

Sogomana Estate, Perak, (referred to as Estate 1 in the Annual Report of 1938), completed its first year in August 1939. Fertiliser effects cannot yet be detected, either in growth or in yield. Comparative tapping results on the two tapping systems are summarised in Table XXX.

TABLE XXX. *Tapping Experiment No. 32. Sogomana Estate. Results of the first year (September 1938 to August 1939)*

Total Dry Rubber (No. 1 sheet plus lower grades)

Tapping System:—	System 1 A.D. on half-circ. S/2,d/2,100%	System 2 D.A.M. on half-circumference S/2,d/1,m/2,106%
Yield in pounds per acre ..	607	
Adjusted Relative Yield	100.0	103.4
Adjusted Relative Tapping cost ...	100.0	96.7
Mean monthly d.r.c.	32.9	31.7
Girth increment (cm./ann.) at 55 inches	3.03	2.77

The daily, alternate-monthly plots (system 2) were given a "flying start," in accordance with Sumatran practice; the resting cuts were reopened by the tappers on the last two afternoons of each month without extra cost to the estate. On this basis the relative intensity of daily alternate-monthly tapping is 106 per cent, and not 100 per cent as would be the case if no flying start were allowed.

The rates of bark consumption on the two systems were equal and the percentage of low grade rubber was also the same. The small gain in yield (3.5 per cent) is inadequate in view of the higher tapping intensity on system 2 which appears to retard growth a little.

As in Experiment No. 31 on Sepang Estate on Prang Besar clones, the daily yield-curve indicated that monthly periods of tapping and rest are too long. The peak of the curve is reached about the eighth day of the month (*i.e.* the tenth serial tapping) and intersects the running-mean curve about the fifteenth. Accordingly, system 2 has been modified to daily alternate-half-monthly

with one preliminary tapping ($S/2, d/1, 0.5m/1, 100\% + d$ per. $0.5m/1 = 106\%$) during the second part of this experiment.

E. Influence of Tapping Height on Yield of Budded Trees

(a) Tapping Experiment No. 48 (R.R.I.E.S. Field 5)

The small-scale experiment, set up five years ago on the border-rows of the Field 5 clone trial at the Experiment Station,

TABLE XXXI. Tapping Experiment No. 48. (R.R.I.E.S. Field 5)

Comparison of Yields of Budded Trees Tapped at Different Heights
Total Dry Rubber (Cup-lump)

Clone	Yield on high cuts as percentage of low cuts (Approx. diff. in tapping height = 20")					No. of trees tapped in 1939	
	1935	1936	1937	1938	1939		
Year							
Age	6	7	8	9	10	High cut	Low cut
Avros 49	88	84	90	91	88	30	30
Avros 50	97	88	97	96	94	30	30
Avros 152	80	114	100	80	77	31	27
B.D. 5	83	95	92	101	115	31	26
Pil. A. 44	87	116	112	109	112	19	31
Pil. B. 84	106	93	113	72	81	27	27
P.B. 23	82	86	87	90	87	27	24
P.B. 186	85	88	91	100	105	29	29
TJ. 1	102	102	106	90	107	31	29
All clones } Total Mean	91	97	99	92	96	255 28	253 28
Seedlings *	54	68	75	61	87	90	89
Tapping heights (means in ins.)	$36\frac{1}{2}/16\frac{1}{2}$	$29\frac{1}{2}/9\frac{1}{2}$	$22\frac{1}{2}/3$	$15\frac{1}{2}/36\frac{1}{2}$	$8\frac{1}{2}/29\frac{1}{2}$		

Tapping System: A.D. on half-circumference without rest. ($S/2, d/2, 100\%$).

* Figures from a similar experiment on seedling trees, growing in Field 6 at the Experiment Station under conditions not unlike those in Field 5, are included for comparison. (These seedlings are one year older than the budgrafts).

to compare yields of budded trees at different tapping heights, has been continued. Tapping commenced in 1935 on two series of trees of each clone, opened at 20 inches and 40 inches from the union respectively and tapped on the system S/2,d/2,100%. In January 1938 the cuts on trees originally opened at 20 inches reached the union and a new panel was opened at 40 inches; the tapping height in this series was 33 inches in January 1939. Cuts on trees of the other series, originally opened at 40 inches, were then about six inches above the union. Yields and other data are summarised in Table XXXI.

During the first three years the yield of the trees tapped at the higher level increased steadily in relation to that of the trees tapped at the lower level. In 1938 when a new high panel was opened, the relative yields from high and low tapping were the same as in 1935, *i.e.* during the first year of the experiment. Comparison between budded trees and seedling trees tapped at the same heights in another experiment shows that the average decrease in yield per inch rise in tapping heights is 0.25 per cent for the budgrafts and 1.6 per cent for the seedling trees.

(b) *Tapping Experiment No. 44 (R.R.I.E.S. Field 22A).*

Results for the first eighteen months in the experiment set up in Field 22A at the Experiment Station to compare the yields of budded trees at different heights of tapping, are summarised in Table XXXII.

The average decline in yield of 0.7 per cent for every inch that the height of the tapping cut is raised found in this experiment is nearly three times as great as that in experiment (a) above.

The figures in Table XXXII show very clearly that the rate of decline in yield is irregular along the length of the tapping panel. The greatest effect is in the top half and centre of the panel from 40 inches to 20 inches, where the maximum yield increase is recorded as the tapping height is lowered. Above 40 inches the effect is not so marked, while at lower levels between 20 inches and 10 inches the yield increase becomes almost negligible.

As before, there is some variation in the effect of the tapping height on individual clones. Table XXXIII gives the relative yield on the high cuts as a percentage of the yield on cuts 20 inches below for each clone for comparison with the data presented in Table XXXI.

Comparing the mean of all clones together, the effect of tapping height on yield is about three times as large in the experiment in Field 22 as in the experiment in Field 5. This discrepancy is particularly marked in the case of Clone Tjirandji 1.

TABLE XXXII. *Tapping Experiment No. 44. (R.R.I.E.S. Field 22A)*
Yields of Budded trees at Different Tapping Heights

Total Dry Rubber (cup-lump) July 1938–December 1939 (239 tappings)

Treatment	Mean yield lb. per tree for 18 months †	Mean height of tapping *		Relative yield at different heights compared with treatments				Percentage decline in yield between one tapping height and next below	
		in.	cm.	1	2	3	4	per in.	per cm.
1	11.6	14.5	36.8	100	103	116	126	0.20	0.08
2	11.3	24.3	61.7	98	100	113	123		
3	10.0	34.3	87.1	86	88	100	109	1.20	0.47
4	9.2	44.1	112.0	79	81	92	100		
								0.82	0.32

* Heights of opening cuts above ground level in July 1938 were as follows:—Treatment (1) at 51 cm. (20"), treatment (2) 76 cm. (30"), treatment (3) at 102 cm. (40") and treatment (4) at 127 cm. (50").

† Tapping system: A.D. on half-circumference. No rest. (S/2,d/2,100%).

Field 22A—budded Dec. 1932 with Avros 49, 152, P.B. 186, Rubana 393 and Tj. 1. Age at opening, 5 years; average age during above period, six years and three months.

TABLE XXXIII. *Tapping Experiment No. 44. Comparison of Yields of Budded Trees. Tapped at Different Heights (R.R.I.E.S. Field 22A)*

Yield on high cuts as percentage of yield on cuts 20 inches below

Clone:—	Avros 49	Avros 152	P.B. 186	Rub. 393	Tj. 1	Mean
Relative yield of high cuts ...	90	81	93	78	85	85
No. of trees ...	30	28	28	36	38	

F. *Influence of Direction of Tapping Cut on Yield of Budded Trees.*
Tapping Experiment No. 37. Pilmoor Estate

The experiment started at Pilmoor Estate in 1933 on mature trees of clone Pilmoor B. 95, to investigate the influence of the direction of the tapping cut on yield, has been continued. The results for the full period of seven years are summarised in Table XXXIV below.

TABLE XXXIV. *Tapping Experiment No. 37. Influence of Direction of Tapping Cut on Yield (Pilmoor Estate, clone Pil. B. 95)*

Total Dry Rubber (Cup-lump)

Year	Mean height tapping cut inches	Yield in grm. per tree per tapping L-to-R cut	Yield R-to-L cut as percentage of yield of L-to-R cut	Percentage loss in yield on R-to-L cuts
1933	35	14.3	74.6	25.4
1934	25	17.7	82.5	17.5
1935	15	18.6	92.0	8.0
1936	5	22.8	95.5	4.5
1937	37½	19.0	76.6	23.4
1938	35	15.8	91.5	8.5
1939	25	28.8	95.3	4.7
		19.6	86.9	13.1

Original cuts opened at 40 inches in January 1933: turned over to new panel at 40 inches on 30/3/37.

Tapping system: A.D. on half-circumference without rest (S/2,d/2,100%).

Tapping on the new panel opened in April 1937 confirms that the relative loss in yield on the right-to-left cut is greatest at the top of the panel and decreases with the lowering of the tapping height. Compared with normal tapping on a left-to-right cut, the mean loss over seven years right-to-left tapping is 13 per cent.

III. Selection and Breeding

NEW CLONES FROM ESTATE MOTHER-TREES (Field 15. S)

The test tapping of these clones has been continued throughout the year and the yields of the best clones are given in Table XXXV. Some of the clones mentioned in previous annual reports have been omitted because of the appearance of bad secondary

characters and several clones which have made big increases in yield during the year are included in the Table for the first time.

All these new clones have yielded at least fifty per cent more than Avros 50, the control clone. As already shown in this report the highest yielding clone in the Clone Trial Experiment in Field 5 in 1939 was Clone Tjirandji 1 which yielded 34 per cent more than Avros 50. On a comparative basis the yields of these new clones compare quite well with the best of the proved clones, though they are evidently much inferior to the clones made from hand-pollinated seedlings the yields of which are given in Table XXXV.

CLONE COLLECTION (Field 15. N)

With a few exceptions these clones are no longer recommended for planting and their interest is mostly historical. On the whole they still show a superiority to the new clones from estate mother-trees but the difference is not so marked as in previous years.

TABLE XXXV. *Yields of New Clones from Estate Mother-Trees (Field 15 South) Yield of Clones in the Clone Collection (Field 15 North)*

Clones from Estate Mother-Trees							Clones from Clone Collection						
Yield in lb. per tree							Yield in lb. per tree						
Clone	1937		1938		1939		Clone	1937		1938		1939	
	Clone	Av. 50	Clone	Av. 50	Clone	Av. 50		Clone	Av. 50	Clone	Av. 50	Clone	Av. 50
R.R.I. 5	3.5	4.4	6.7	5.0	10.8	5.6	Av. 150	6.1	3.1	9.0	4.4	11.4	5.4
" 24	6.5	3.6	6.5	4.5	9.2	6.0	Av. 163	5.3	2.5	9.2	3.7	12.0	5.5
" 27	4.8	4.1	6.2	4.8	9.2	5.7	P.B. 24	4.6	4.3	7.2	5.5	9.6	4.4
" 28	4.2	4.5	6.3	4.0	9.4	5.4	P.B. 31	6.1	3.2	6.1	4.5	9.8	5.7
" 49	5.4	4.0	7.1	5.4	9.8	5.2	P.B. 49	5.8	3.5	8.8	4.4	12.0	6.4
" 54	4.0	2.7	6.2	4.8	8.5	5.9	P.B. 86	6.2	3.8	9.2	6.1	9.0	4.5
" 83	3.6	2.5	6.0	4.3	8.3	5.5	P.B. 123	9.1	3.1	9.6	5.4	12.0	5.0
" 88	4.8	3.7	6.8	3.9	8.6	5.6	P.B. 155	7.1	2.8	9.8	4.4	9.9	3.9
" 99	5.4	3.8	6.8	4.5	10.7	6.4	P.B. 183	3.8	3.1	5.8	4.0	8.7	3.9
" 103	7.0	4.4	6.2	5.3	9.9	6.4	Dj. 1	3.6	2.8	6.2	5.0	9.0	7.1
" 107	5.4	3.8	7.8	4.4	11.5	4.4	P.E. 26	7.1	2.3	10.0	4.8	12.0	5.9
" 138	5.9	3.3	6.0	4.4	9.0	4.4	B.R. 2	3.9	2.9	6.1	6.1	8.6	7.9
" 140	6.3	5.0	6.3	4.8	8.5	5.2	Lun. N	7.4	3.9	9.0	3.9	10.5	6.0
" 142	6.8	3.5	7.5	4.4	11.5	5.3	R.A. 22	9.2	2.9	10.7	4.5	13.8	4.4
" 147	7.7	4.1	7.6	4.0	8.6	5.6	R.A. 23	10.1	3.8	10.0	5.9	14.0	7.4
" 178	—	—	4.5	2.5	9.5	4.6	Pil B. 16	4.4	3.6	8.0	5.3	9.7	5.0
" 195	—	—	4.9	3.6	8.1	4.4	G. 11	5.2	2.4	8.8	4.4	9.2	5.2
							K. 80	5.4	3.3	8.1	4.3	9.1	5.0
							Sab. 3	—	—	5.1	3.0	6.2	4.0

SELECTION OF NEW CLONES ON ESTATES

Many estates have established new clones from high-yielding trees and advice on the method to be adopted in testing these clones and assistance in the recording of the yields has been given.

In the case of the oldest clones this work has been carried on without interruption since 1928.

BREEDING INVESTIGATIONS

Only a comparatively small programme of hand pollinations was undertaken in 1939 and the detailed results are set out in Table XXXVI.

TABLE XXXVI. *Results of Hand Pollinations 1939*

No.	Cross	No. of pollinations	No. of fruits harvested	% Success	No. of seeds planted	No. of seeds germinated	% Germination
1	Lund. N $\times$ B. 84 -	418	21	5.0	63	16	25.1
2	B. 84 $\times$ Lund. N -	303	—	—	—	—	—
3	Lund. N $\times$ R.R.I. 500 -	39	1	2.6	3	—	—
4	Lund. N $\times$ Tj. 1 -	333	10	3.0	30	6	20.0
5	Tj. 1 $\times$ Lund. N -	48	—	—	—	—	—
6	Lund. N $\times$ R.R.I. 506 -	200	1	0.5	3	—	—
7	Lund. N $\times$ R.R.I. 501 -	563	14	2.5	41	13	31.7
8	R.R.I. 501 $\times$ Lund. N -	339	16	4.7	48	36	75.0
9	B.R. 2 $\times$ B. 84 -	111	—	—	—	—	—
10	B.R. 2 $\times$ R.R.I. 500 -	28	4	14.2	13	5	38.4
		2382	67	2.4	201	76	37.8

The percentage of successes was very much lower than that obtained in previous years and these disappointing results must be attributed to the exceptionally dry weather that prevailed during the period between pollination and harvesting.

Of the seeds obtained only 38 per cent germinated compared with an average of over 90 per cent in 1937 and 1938. This poor

germination can be in part accounted for by the very dry weather which caused an unusually high proportion of light seed, but the principal reason for this poor success must be attributed to the failure of the water supply shortly after the seeds were put into baskets. The seeds from cross No. 8, R.R.I. 501 × Lun. N and from the large-scale pollination between Tjirandji 1 and Pilmoor B. 84 were harvested later when there was plenty of water available and showed better germination.

A first attempt at the large-scale production of hand-pollinated seedlings was made using Tamil boys as pollinators. The results which are given below were equally unsatisfactory.

TABLE XXXVII. *Large-scale Hand Pollinations, 1939*

Crosses		No. of pollinations	No. of fruits	% Success	No. of germinated seeds
Tj. 1 × B. 84	...	11,040	320	2.9	1,011
B. 84 × Tj. 1	...	5,961	35	0.6	
		17,001	355	2.1	

Of the 1,011 seeds of the cross between Tjirandji 1 and Pilmoor B. 84, 650 were distributed to estates for experimental purposes.

The conditions for the production of hand-pollinated seeds were too unfavourable for any conclusions to be drawn as to the fertility of the different crosses, but the particularly poor results obtained when using B. 84 as a mother confirms the experience of previous years.

LEGITIMATE SEEDLING FAMILIES OBTAINED BY HAND POLLINATION

The previous yields and a description of the characteristics of the families of crosses made during the years 1928 to 1931 have already appeared in the *Journal* (Vol. 10, Communication No. 248, 1940) and the yields for 1939 which will be found in Table XXXVIII are in continuation of those already published. Substantial increases in yield are shown in the families A. 44 and B. 84, B. 58 and B. 84, and B. 84 and B. 16.

TABLE XXXVIII. *Yields for 1939 of the Legitimate**Mean Yield in lb. per tree*

Parents	1st Series Age on 1.1.39 9 years 8 months		2nd Series Age on 1.1.39 9 years 3 months		3rd Series Age on 1.1.39 8 years 8 months	
	No. of trees	Mean Yield	No. of trees	Mean Yield	No. of trees	Mean Yield
A. 8 & A.44	6-7	9.4				
A. 8 & B.58	19-21	12.0				
A.44 & B.58	13	15.5	54	13.8	21	13.4
A.44 & D.61	74-76	14.1	36	14.6	107-108	14.1
A.44 & B.16	30	16.1			118-119	16.1
A.44 & B.84	7	21.2	31	17.7	43-42	17.2
B.58 & D.61	8	11.1				
B.58 & B.16	11-12	17.3			7	22.4
D.61 & B.16	6	8.6			19	9.4
A.44 & B.50			19-20	10.4		
D.65 & A.44					5	8.7
B.50 & B.58			25	11.1		
B.58 & B.84			14	20.8		
B.84 & D.61			51-52	14.6		
B.84 & B.16					37	18.9
D.65 & B.16					9	13.6
A.44 & B.65						
D.61 Selfed					1	5.6
D.65 & B.84						
B.50 & B.84						
B.58 & D.65						
B.58 & B.65						
C.72 & B.84			6	22.9		
B.58 & C.72			3	23.6		
B.90 & B.16						
B.50 & E.95			3	11.4		
B.95 & A.44	9	14.6				
A.44 & Lun. N					17	17.7
B.84 & Lun. B						
Lun. K & Lun. N					2-1	6.7
A.44 Selfed					3	6.9
B.58 & B.90					3	8.4
D.65 & D.61						
B.11 & D.65						
D.61 & G. 1						
B.84 & G. 1						
B.58 & G. 1						

LEGITIMATE SEEDLINGS FROM 1937 CROSSES

The seedlings raised by hand pollination in 1937 were planted in the nursery at the end of that year. In October these seedlings were stumped and planted in Field 33.

*Seedling Families of the 1928-1931 Series**per annum estimated on 160 tapping days*

4th Series Age on 1.1.39 8 years 3 months		5th Series Age on 1.1.39 7 years 8 months		6th Series Age on 1.1.39 7 years 3 months		7th Series Age on 1.1.39 6 years 8 months	
No. of trees	Mean Yield	No. of trees	Mean Yield	No. of trees	Mean Yield	No. of trees	Mean Yield
84-89	11.4			123-129	8.5		
				40-43	8.8		
		25	7.7				
23	11.3			3	16.1		
		1	9.2				
15	7.9						
8	13.0	37	13.0				
17	9.2	34	4.6				
2	9.4						
		18-19	6.3				
		6	9.2				
7	4.6						
		3	6.8	76-78	10.2		
		7	3.6				
						28-40	8.0
						13-15	9.2
						5-6	4.8

Two experiments were set up in which the twenty-five families of hand-pollinated seedlings were arranged in 190 plots of four trees with buddings of B. 84 as a control.

In addition 131 surplus stumps not required in the experiment were planted at the same time.

These experiments were designed by the Statistician after the method devised by Hutchinson and Panse.

NEW CLONES FROM LEGITIMATE SEEDLINGS

Seven more clones obtained from legitimate seedlings of the 1928 to 1931 series of crosses have been selected for further testing on a larger scale and their yields together with those from the first selection of clones are given in Table XXXIX.

It will be noted that thirteen clones have been dropped from the list published in the Annual Report for 1938. These clones appear to have inherited the precocity of A. 44 and have not maintained the promise of their early yields.

CLONES FROM 1937 CROSSES

When the seedling trees of the 1937 crosses were cut back in the nursery in preparation for planting as stumps, the tops were taken to the field and used as budwood. In this way 778 new clones from hand-pollinated seedlings were established on a small scale in Fields 32 and 33 with B. 84 as a control.

YIELDS OF ILLEGITIMATE SEEDLINGS OF HIGH-YIELDING CLONES

The yields of the more important families of illegitimate seedlings from five fields on the Experiment Station are shown in Table XL.

In Field 25 IV a new tapping panel was opened in July at 30 inches from the ground in consequence of which there has been a general decline in the yields of all families. In the other fields tapping was continued on the same tapping panel as in 1938 and there has been a good increase in yield throughout.

Seedlings from clone B. 84 continue to be the highest-yielding family in the three oldest fields, though the amount by which its yield exceeds that of the other families varies considerably. This variation is probably in part due to differences in the pollen parents of the trees in three consecutive seeding seasons.

In the younger fields the seedlings of clones Prang Besar 49, 86, 24, 25, Sungei Reko 9 and Sabrang 24 continue to give good yields.

In comparing the yields of the three families of seedlings of the Avros clones with the other trees in Field 17D North it should be noted that the former were planted as basket plants at the same time that the latter were planted as stumps. This could in part account for the lower yields obtained from the illegitimate seedlings of the Avros clones.

TABLE XXXIX. *Yield of a Selection of Clones made from Legitimate Seedlings of the 1928-1931 Series*

Clone	Origin of Mother-Tree	Date budded	No of trees tapped	Yield lb. per tree per annum				Brown Bast	Wind Damage
				1936	1937	1938	1939		
500	B. 84 x A. 44	Nov. 1930	3 3.3.4.4.	13.1 13.1	15.9 15.9	21.0 17.9	24.5 21.0	—	—
501	A. 44 x Lun. N	Oct. 1931	1 2.2.2.1.	8.9 9.3	18.2 18.2	25.3 26.3	26.0 25.1	—	—
502	B. 16 x A. 44	Nov. 1930	3 3.4.4.4.	9.1 9.1	10.1 8.7	15.4 13.5	20.6 18.8	—	1
505	A. 44 x Lun. N	Oct. 1931	2 3.3.3.2.	8.9 7.1	11.6 10.4	14.8 13.6	15.3 16.4	—	—
506	B. 84 x A. 44	Nov. 1931	2 3.3.3.2.	6.5 7.6	11.8 13.8	15.5 16.1	22.5 22.5	1	1
509	A. 44 x Lun. N	Oct. 1931	2 3.5.5.5.	9.5 9.2	14.0 12.6	11.8 11.4	16.7 18.2	1	—
511	A. 44 x B. 16	Nov. 1931	3 3.4.5.4.	8.1 8.1	14.0 13.3	16.4 14.2	19.2 16.9	1	—
512	B. 84 x A. 44	Jun. 1932	2 2.3.3.3.	6.0 6.0	11.2 10.3	13.5 12.3	17.8 15.7	—	2
514	A. 44 x B. 58	Oct. 1931	4 4.5.5.5.	7.1 7.1	16.0 14.6	18.2 15.1	20.4 17.6	—	1
515	A. 44 x D. 61	Oct. 1931	2 3.3.3.2.	6.5 6.4	14.2 13.9	17.2 17.0	19.9 19.9	1	—
523	A. 44 x B. 16	Oct. 1931	3 3.3.3.3.	5.2 5.2	11.4 11.4	14.2 14.2	18.2 18.2	—	—
524	A. 44 x B. 16	Oct. 1931	1 1.1.1.1.	4.4 4.4	11.4 11.4	19.0 19.0	24.6 24.6	—	—
525	B. 84 x D. 65	Apr. 1933	2 2.3.3.	—	7.5 7.5	14.9 11.9	19.3 15.6	—	—
526	B. 84 x D. 65	Apr. 1933	3 3.3.3.	—	4.1 4.1	11.6 11.6	18.7 18.7	—	1
527	B. 50 x B. 84	Jun. 1932	3 3.5.6.	—	8.2 8.6	14.5 11.5	24.5 18.7	—	—
528	B. 84 x D. 65	Apr. 1933	2 2.4.4.	—	4.4 3.6	9.8 8.4	16.2 13.6	—	—
529	B. 84 x D. 65	Apr. 1933	2 2.2.	—	—	9.3 9.3	15.4 15.4	—	—

Note 1 Under the heading "No. of trees tapped" the upper figure refers to the number of trees tapped continuously throughout the whole period and the lower figure to the number tapped in each tapping year.

Note 2 Two figures are given for the yield of each clone in each tapping year. The upper figure refers only to the yield of those trees tapped continuously throughout the period shown, the lower figure gives the yield of all the trees tapped including trees too small to tap in the first year and trees taken out of tapping in later years because of disease or wind-damage.

TABLE XI. *Yield of Illegitimate Clonal Seedlings from various fields on the Experiment Station*

Origin of Family	Field and Date of Planting	No. of trees in tapping 1939	Yield in lb. per tree per annum. 160 tapping days				
			1935	1936	1937	1938	1939
Pil. A. 44	Field 4 (A) April 1929	151-156	5.8	8.0	9.8	11.8	13.3
" B. 58		76-77	4.6	6.4	8.3	10.5	12.7
" B. 84		20	5.6	8.2	11.6	15.8	19.9
" B. 16		8	2.7	5.3	6.3	7.4	12.1
Pil. A. 44	Field 16 (N) Nov. 1929	63-62	3.8	5.9	8.8	9.2	12.8
" B. 58		65-66	2.9	5.0	7.5	7.5	11.2
" B. 84		142-144	4.0	7.0	10.5	11.0	15.8
Pil. A. 44	Field 16 (S) April 1930	28	3.6	5.6	8.8	8.7	12.0
" B. 58		18	3.0	5.0	8.7	7.7	12.5
" B. 84		11	2.5	5.2	9.0	7.2	12.8
" B. 16		37	2.5	4.8	8.1	7.4	11.6
" D. 65		45	2.3	3.6	6.7	7.7	12.3
P.B. 8	Field 25 (IV) Dec. 1931	19-22	—	—	6.4	10.1	8.5
" 24		13-20	—	—	5.3	8.1	6.9
" 49		18-19	—	—	7.7	11.8	10.4
" 86		38-41	—	—	6.5	10.7	9.6
Glen. 1		23-24	—	—	3.2	5.3	5.2
Sab. 24		19-20	—	—	5.9	9.6	9.0
S.R. 9		26-30	—	—	6.4	10.6	9.4
Pil. D. 65	Field 17 D (N) Nov. 1932	16	—	—	—	4.4	6.3
P.B. 24		14-15	—	—	—	5.5	7.9
" 25		30-32	—	—	—	5.1	7.8
Glen. 1		31	—	—	—	3.8	5.9
Sab. 24		97-91	—	—	—	5.0	6.3
S.R. 9		74-80	—	—	—	5.5	7.5
Avros 50		15	—	—	—	2.3	4.0
" 49		17	—	—	—	3.4	4.6
" 152		19	—	—	—	4.9	6.1

SEEDLINGS FROM ISOLATED SEED GARDENS

The yields of the twenty-five families of seedling trees grown from seed from the Tjikadoe Isolated Seed Gardens are given in Table XLI. These trees have been tapped alternate-daily on a half-circumference cut continuously since January 1935.

TABLE XLI. *Summary of Yield Records of Families of Seedlings from the Tjikadoe Isolated Seed Gardens (Age 1939—10½ to 11½ years)*

Family	Number of Trees Tapped					Yield in lb. per Tree				
	1935	1936	1937	1938	1939	1935	1936	1937	1938	1939
1	9	9	9	9	9	6.6	10.5	12.2	13.6	20.2
2	13	12	12	11	12	7.0	11.6	14.4	20.4	24.9
3	9	10	10	11	13	4.0	7.2	8.5	13.0	15.9
4	8	10	11	11	10	3.2	5.2	7.3	10.0	13.5
5	10	13	14	13	14	2.9	5.1	4.6	6.7	9.4
6	8	11	11	10	10	6.3	9.1	12.3	19.1	21.6
7	12	12	12	12	12	6.5	12.2	14.4	20.2	24.6
8	9	11	11	11	11	3.7	6.2	7.8	10.4	13.1
9	4	5	5	5	5	5.4	9.6	14.1	20.8	27.8
10	10	9	8	7	8	9.6	17.4	15.5	16.6	26.3
11	10	9	9	9	9	3.4	6.6	6.5	4.5	12.0
12	7	7	7	7	7	4.5	9.0	9.5	14.5	22.7
13	6	9	8	6	6	5.5	5.8	6.7	11.0	14.5
14	6	6	6	6	6	4.1	9.4	11.9	18.7	21.9
15	14	13	13	13	12	7.0	11.1	14.3	20.4	28.6
16	4	7	6	16	8	3.6	4.7	7.0	8.8	10.5
17	9	10	8	9	10	8.4	12.2	21.7	26.4	29.4
18	10	10	10	10	10	4.3	7.2	9.2	13.2	15.0
19	12	13	13	13	13	4.6	7.1	8.6	11.8	17.8
20	15	15	11	13	14	9.2	16.8	18.4	23.7	32.9
21	6	8	8	8	8	11.3	9.6	12.0	15.8	29.1
22	9	9	9	9	9	5.6	10.8	14.0	24.8	29.6
23	9	9	9	9	8	5.2	7.7	9.4	14.0	16.2
24	9	10	10	11	12	5.5	8.7	11.5	16.3	20.9
25	7	7	7	8	8	3.1	3.7	5.2	10.0	15.1
All Trees	225	244	237	237	244	5.5	9.0	11.1	15.4	20.5

The present tapping panel was opened at 32 inches from ground level in July 1937 and the cuts reached the junction of virgin bark and first renewal just before the end of the year.

The average increase in yield of five pounds per tree must be accounted very satisfactory even though the original planting distance of 30 feet by 30 feet has undoubtedly given the trees a great advantage.

On the whole the different families have kept much the same order of merit throughout the five years but there are certain notable exceptions. Families 10 and 13 after a good start have shown a comparatively slow rate of increase and families 9 and 22 a comparatively rapid one.

Family 21 has behaved very erratically. In the first tapping year it yielded more than twice the average for all families; in the second, third and fourth years the yield was only a little above the average; but in the fifth year it almost doubled its yield and came into fourth place.

EARLY DETERMINATION OF YIELDING QUALITIES OF SEEDLINGS

Correlations between the yields from short periods of test-tapping and the yields obtained during continuous tapping S/2,d/2,100% on a group of seedling trees in Field 2 are given in Table XLII. Most of the trees consist of seedlings from the Tjikadoe isolated seed gardens.

TABLE XLII. *Relationship between Yields at Test-tapping and Yields obtained under Continuous Tapping*

No. of Test-tapping	Age of trees at Test-tapping years	Correlation Coefficient between Yield on Test-tapping and Yield on Continuous tapping				
		6½-7½ years	7½-8½ years	8½-9½ years	9½-10½ years	10½-11½ years
1	3½	+ 0.77	+ 0.68	+ 0.58	+ 0.46	+ 0.48
2	3½	+ 0.75	+ 0.76	+ 0.64	+ 0.53	+ 0.53
3	4½	+ 0.85	+ 0.77	+ 0.69	+ 0.69	+ 0.60
4	4½	+ 0.83	+ 0.86	+ 0.65	+ 0.54	+ 0.54
5	5½	+ 0.80	+ 0.80	+ 0.70	+ 0.59	+ 0.62
6	5½	+ 0.85	+ 0.83	+ 0.74	+ 0.64	+ 0.64

The value of the correlation coefficient fell steadily during the first four years of continuous tapping, but no further fall occurred during the fifth year.

In 1940 the tapping cut will be on the renewed bark of the original test-tapping panels, and it will be interesting to see if this has any effect on the value of the coefficients.

IV. Physiological Investigations

NUTRITION: POT-CULTURE EXPERIMENTS

These experiments were described in detail in the Annual Report for 1938.

Characteristic leaf symptoms of extreme deficiency of nitrogen, phosphorus and magnesium have appeared during the year, those of nitrogen and magnesium deficiencies for some months past and that of phosphorus deficiency very late in the year. Leaf symptoms of potassium and calcium deficiencies have not yet developed and it has been decided to postpone the sampling of leaves for chemical analysis until these symptoms appear, when leaves from all series can be sampled at the same time.

It was noted that the foliage of plants in most series developed symptoms of magnesium deficiency owing presumably to the high potassium: magnesium ratio of the nutrient solution. Wallace, at the Long Ashton Research Station, observed the same effect; the lowering of this ratio has resulted in a considerable improvement in the appearance of the foliage.

Series A—Complete Nutrient Solution

The leaves in this series were well developed and a healthy green colour when young but later became chlorotic along the margins and between the veins. There has been no pronounced defoliation and at no time have the plants been leafless.

Series B—Nitrogen Omitted

This is the most drastic treatment in this experiment and abnormal foliage characters were noted at an early stage. The leaves were small with pointed tips and a pale yellowish-green to yellow in colour. The amount of foliage is much reduced and leaves are retained only on the uppermost storeys.

The plants shed their leaves for the first time in February, when two storeys of leaves had been formed, and again in July and November. Defoliation was almost invariably preceded by scorching of the leaf margins and the new leaves produced after

defoliation showed the same characteristics as the first-formed leaves.

The plants are stunted in growth, elongation of the main stem ceased early and the lateral shoots which are slender with light brown to yellowish bark have a tendency to die back.

Series C—Phosphorus Omitted

Except that the foliage has remained a darker green the growth of the plants in this series resembles more closely that of series B than that of any other treatment. Growth in length and in thickness of the main stem ceased early and the lateral shoots are short and slender.

The leaves are considerably reduced in size and have a bronzed appearance. This bronzing of the leaves was first observed in January 1939 but it was not until late in the year that the purplish anthocyanin pigmentation characteristic of extreme phosphorus deficiency began to appear on a few leaves.

The plants shed their leaves twice during the year, in March and August, and refoliation after the second leaf-fall was extremely slow.

No leaf-scorch has been observed.

Series D—Potassium Omitted

The leaves in this series are well developed and of normal size. The young leaves are a healthy green colour but the older ones show yellowing between the veins and almost invariably develop scorch at the tip before abscission.

No marginal leaf-scorch or premature leaf-abscission have yet been observed. Shoot-growth is only very slightly restricted compared with Series A.

Series E—Calcium Omitted

The general growth and vigour of the plants in this series is well in advance of that in Series A. The leaves are in general larger than those of the plants receiving the complete nutrient solution. The lower leaves show yellowing between the veins and in a few isolated cases patches of dead tissue ("blotches") have been observed on these leaves.

Series F—Magnesium Omitted

The general development of the plants in this series is only very little inferior to that in Series A.

The leaves, which are of normal size, are a healthy green colour when young but later develop the characteristic yellowing

between the veins and at the margins, where they also show numerous dead patches. The dead patches between the veins cause premature abscission of the leaves.

Series G—Minor Elements Omitted

Leaf symptoms other than those noted in Series F have not been observed in this series. Shoot-growth is restricted and the general development of the plants is superior only to that in Series B and C.

Comparative data of shoot-growth in the different series are shown in Table XLIII.

TABLE XLIII. *Growth data for Hevea in Pot-culture*

Series	Treatment	Number of plants	Total shoot growth in cm.	Average shoot-growth per plant (cm.)
E	Calcium omitted	15	9057	604
A	Complete nutrient	15	6894	460
F	Magnesium omitted	15	6653	443
D	Potassium "	15	6282	419
G	Minor elements "	10	3619	362
C	Phosphorus "	15	1754	117
B	Nitrogen "	15	1099	73

It is interesting to note that the order of the treatments is identical with that obtained by Wallace at the Long Ashton Research Station for shoot-growth of apple trees.

TREATMENT WITH GROWTH SUBSTANCE FOR THE STIMULATION OF BARK RENEWAL IN HEVEA

Two experiments have been started to test the effect of the frequency of applications of palm oil and palm-oil sludge on the rate of renewal of the bark of budded trees and to ascertain whether the stimulation is due to growth substances, vitamins or auxins, contained in the palm oil or to the physical effects of the oil layer.

TREATMENT OF SEED WITH GROWTH SUBSTANCES

Mixed clonal seeds were soaked in 0.01 per cent solutions of three synthetic auxins (beta-indolyl-acetic acid, beta-indolyl-butyric acid and alpha-naphthalene-acetic acid) for 24 hours prior to planting.

Germination results and growth data obtained six months after planting are given below.

TABLE XLIV. *Germination after treatment with Growth Substances*

Treatment	No. treated	Percentage germinated	Average height in inches
Indolyl acetic acid 0.01% ...	105	62	27.4
Indolyl butyric acid 0.01% ...	105	64	25.5
Alpha-naphthalene acetic acid 0.01% ...	105	57	26.8
Tap Water (Control) ...	105	64	24.4

Treatment with growth substance has not increased the percentage germination and has not appreciably affected the subsequent growth of the seedlings.

Further experiments are in progress to investigate the effect of growth substances on basket seedlings of Hevea and on seeds and cuttings of leguminous cover plants.

STIMULATION OF CALLUS GROWTH ON THE STOCKS OF BUDDED TREES

The stocks of buddings in Field 30A were pruned at a steep angle in May and the exposed surface was coated with a thick layer of the preparations listed in Table XLV.

The results show that "Treheal" and possibly product 2295DD have had some beneficial effect on the rate of callus growth. Product 2295A and "Socony tree ointment" have had a slight retarding effect and "Rubber tree sealing compound" has been definitely harmful. Indolyl acetic acid in lanolin (all three concentrations used) has slightly accelerated the rate of callus growth.

TABLE XLV. *The Effect of various treatments on the Healing of the Snags of Budded Trees.*

Treatment	Number of trees	Average girth of stock below union in May cm.	Length x breadth of uncallused area of pruning cut on 23rd November expressed as % of same in May	Percentage of callusing after 6 months
Product 2295A	- 50	29.3	56.4	43.6
Product 2295DD	- 50	29.9	43.4	56.6
Rubber tree sealing compound	50	32.1	122.6*	- 22.6*
Secony tree ointment	- 50	27.3	56.8	43.2
"Treheal"	- 25	32.4	35.0	65.0
Control (untreated)	- 50	29.9	46.3	53.7
Indolyl-acetic-acid in lanolin 1: 5,000	- 15	32.7	33.9	66.1
" " 1:10,000	- 15	29.9	41.7	58.3
" " 1:50,000	- 15	31.1	38.0	62.0
Control (lanolin only)	- 15	32.0	45.0	55.0

*Die-back of bark observed in 68% of cases.

ANATOMICAL INVESTIGATIONS

Examination of bark structure and correlation between bark characters and yield of Hevea

A preliminary study of the structure of sieve-tubes and latex vessels in relation to yield of a small group of clonal seedlings was completed during the year. The objects of this investigation were to develop a technique for measuring the structure of those tissues, which could be adopted for a further more detailed investigation and to measure the correlation between the structure of these tissues and the yield of the trees. (Ref. Yield Prediction in *Hevea*, J.R.R.I.M. vol. 6, pp. 8—20).

This investigation will be extended in 1940 on bark samples which have been collected from 300 legitimate seedlings of the 1937 series of crosses.

V. Ecological Studies

CULTIVATION OF RUBBER TREES IN ASSOCIATION WITH INDIGENOUS PLANTS AND LEGUMINOUS COVERS

An account of the experiment in Field 27 at the Experiment Station, in which five systems of planting cover crops are being compared, was given in the Annual Report for 1938 pp. 106—107. By the end of the year the seedling rubber had begun to form a close canopy and the effect of the shade on the covers is becoming apparent in all treatments.

The present condition of the different treatments is described below.

Treatment 1. Natural covers with minimum control. In May the five plots of this treatment were divided into halves in an east-west direction. In the northern half-plots the covers were cut back to ground level and the debris was cut up and mulched between the terraces. *Centrosema pubescens* was planted in drills above and below the terraces in June but since the germination was very poor a second planting was necessary in September. By the end of the year adventitious shoots had grown from the stumps of the natural cover plants and formed a bushy growth, the most vigorous shoots reaching a height of six feet. Although the co-dominant species *Nephrolepis* and wild ginger (*Hornstedtia* spp.), are reappearing freely throughout the half plots, they are not spreading so rapidly nor growing so vigorously as before. It seems that the clearing and mulching operations and the increasing density of the shade have proved a severe check to their development. There is at present sufficient debris remaining undecomposed on the surface to check any serious wash by rain.

In the southern half-plots no apparent change in the condition of the covers from that described in the last annual report is noticeable.

In treatments 2 and 3, where natural covers are slashed at a height of four feet at half-yearly intervals, ferns being also eradicated in treatment 3, the only change to be reported is a general weakening in growth of many plants as a result of the increasing density of the shade.

In treatment 4 where leguminous bushes were established with *Desmodium ovalifolium*, Lamtoro is the only survivor of the original covers, but under shady conditions it is not recovering well after the periodical slashings. *Desmodium* which at first formed an excellent cover has died off completely except in a few isolated patches on steep slopes.

At the same time that *Desmodium* was planted on the outer edges of the terraces, *Clitoria cajanifolia* was planted on the inner edges. The latter did not establish itself satisfactorily during 1937 and 1938, but when *Desmodium* began to die off self-sown seedlings of *Clitoria* sprang up on and between the terraces. It is now very common, but owing to its weak and wiry growth under shade it does not form a satisfactory cover.

In the plots planted with creeping legumes (Treatment 5) *Pueraria* has died off completely. *Centrosema pubescens* is spreading slowly, but it does not provide an adequate check to soil erosion. Basic slag, at the rate of 2 cwts. per acre, was applied in November 1939 to assist the growth and spread of this cover.

Experiments on Estates

Botanical surveys on three other experimental areas have been continued. Additional data on the principal species growing under different treatments in different districts, and their succession, are being collected.

ERADICATING JUNGLE TREES BY POISONING

In 1938 an experiment was set up in Field 35 on the Experiment Station to compare planting after felling the jungle in the normal way with planting after killing the trees by frill-girdling and poisoning with sodium arsenite.

The control plots were budded in August, but since many of the dead trees were still standing in the poisoned plots budding could not be undertaken owing to the danger from falling trees and branches. The growth however appears to be excellent and it is expected that budding will be possible in April 1940, two years after planting.

In November all the trees in the frill-girdled plots which had not been killed were felled. Altogether seventy-nine trees in the fifteen acres of frill-girdled plots had survived the poisoning. Of these, twenty-eight had either not been treated with poison at all or had been incompletely girdled. The reason for the failure of the poison to kill the other fifty-one trees could not be determined.

GERMINATION OF SEEDS OF *Pueraria phaseoloides*

During the last three years a number of germination tests have been carried out on seeds of *Pueraria phaseoloides* obtained from different sources. The results of these tests show that the average germination of untreated seeds is about 20%. Some

preliminary experiments were done during 1939 on a sample of imported seeds. These consisted mainly of soaking the seeds in water at temperatures above the normal. Treatments which gave promising results were (1) immersing the seeds in water previously heated to 70°C, and allowing it to cool down and remain in it for 24 hours and (2) keeping seeds immersed in water at a constant temperature of about 50°C for 24 hours. By these treatments the germination of a sample of seeds was increased from 18.4% to 46.8% and 51.2% respectively. Both treatments are quite simple, the second particularly so since a smoke-house will provide the conditions required. These treatments have been recommended for general use on estates to improve the germination of seeds of *Pueraria* and *Centrosema*.

VI. Field Experiments on the R.R.I. Experiment Station

One addition is to be made to the schedule of fields planted on the Experiment Station for the experimental work of this Division.

Field	Area acres	Description of Experiment	Date of commencement
38	59	Trial of families of legitimate seedlings, and small-scale clone trial.	August 1939

VII. Field Experiments on Estates

After the close of the first restriction period at the end of 1938 the acreage of all areas planted under the Experimental Planting Scheme was checked, and where necessary adjustments were made in the areas approved by the Controller of Rubber. The agreed total of acreage planted thus differs slightly from that published in the Annual Report for 1938, and now stands at 8,108 acres.

The general division of experiments into their various categories has been indicated in previous reports. A fuller classification showing the essential details of each experimental category will be published separately (see p. 36).

There still remain 11 experiments to be budded in 1940, and in some of these the final scheme has not yet been decided. The growth of the unbudded seedlings in such experiments is being used as an index of soil heterogeneity and on this is based the final lay-out.

WEATHER CONDITIONS

The abnormally dry weather experienced in almost every district of Malaya during 1939, following 1938 which also had sub-normal rainfall, resulted in comparatively poor growth of the rubber plants, which in turn is reflected in the number of areas still remaining to be budded. These circumstances have imposed considerable difficulties on estate managers, and have put a heavy strain on our supplies of budwood upon which large demands were made for supply budding.

The short rainy season began earlier than usual and encouraged estates to carry out budding which had been found impossible to complete the previous September-November. This wet spell proved to be of short duration, and the subsequent dry weather, which lasted in many places from April till September or later, had in some cases disastrous effects on the results obtained. The quality of the budwood we had to supply, particularly that of Pilmoor B. 84, suffered from the same cause.

BUDDING SUCCESSES

Records have been kept of budding results on all estates using budwood from our nurseries at the Experiment Station. Although more data will be obtained during 1940, it is thought that the records so far accumulated are sufficiently extensive to give useful

TABLE XLVI. *Record of Budding Successes obtained by estates co-operating in the Experimental Planting Scheme*

Clone	No. of Records	Total No. of Buddings made	No. of Successes (Final)	Budding Success (Percent- age)	No. of Successes per yard of budwood
P.B. 86 -	13	13699	9751	71	12.75
Pil. B. 84 -	67	54309	40107	74	9.00
Pil. D. 65 -	8	4503	2494	55	10.40
Glenshiel 1 -	17	10498	6851	65	10.90
Lunderston N -	5	3711	3471	93	13.90
Tjirandji 1 -	17	27374	22069	81	11.90
Tjirandji 16 -	16	12394	8098	65	10.40
B.D. 5 -	7	2347	1713	73	11.00

average figures for budding successes, and will be of interest to those who are about to lay down multiplication nurseries in the near future. (Table XLVI).

The R.R.I. clones and some of the less important proved clones are not included in the above table. Additional records will be obtained for the R.R.I. clones during the 1940 season, and these will be awaited before summarizing the results.

The figures for percentage budding successes do not necessarily represent the average success likely to be achieved for each clone under normal conditions because the records include some budding rounds which were carried out at most unfavourable seasons. They have been included so that a better appreciation may be obtained of the figures in the final column. Thus, for example, the low percentage successes achieved with Pil. D. 65 and Tjirandji 16 have been well offset by the comparatively high number of usable buds per yard of budwood of those clones. On the other hand 10-20 per cent better budding success was obtained with Pilmoor B. 84 than with D. 65 and Tj. 16, but this was insufficient to give the same number of budding successes per yard as was found with either of those two clones.

It is interesting that the final successes per yard of budwood show comparatively small variations. On the basis of this table an arbitrary figure of "10 successes per yard" would be justified as an estimate of the budwood requirements of all the clones and would give sufficient allowance for unfavourable weather, inefficient technique etc. For some clones this may be considered too conservative an estimate, but when large budding programmes are being projected well in advance this would be an error on the safe side.

CLONAL SEED TRIALS

Some 11,000 additional seeds or stumps were distributed to 10 estates undertaking trials of various clonal seedling families. Only in one case were large quantities required, in an area where a considerable proportion of the experiment had been destroyed by fire and required replanting.

Girth measurements have been taken in four experiments established earlier than the above with seedling material of particular interest to the estates or agencies concerned. The records are of a preliminary nature and do not yet merit publication. In one experiment, however, it is of interest to record that the growth of Tjirandji 1 selfed-seed, collected from a large monoclonal block, is significantly inferior to that of Tj. 1 $\times$ Avros 157 and other crosses in which the last-named clone is one of the parents.

STOCK EXPERIMENTS

Three estates are undertaking stock experiments but only one has up to the present been budded. The two others were planted late in 1938 and were not sufficiently advanced by the following autumn to be budded uniformly over the whole area.

CLONE TRIALS

Those experiments already budded are still too young for comparative growth measurements to serve any useful purpose. All experiments are being well maintained and supplied, and when periodic visits of inspection are paid to the estates notes are made on the general performance of clones under the varying soil and climatic conditions.

Amongst the better-known proved clones, Pilmoor B. 84 is characteristically one of the slowest growers in the first two years after budding. This is in keeping with its observed performance on the R.R.I. Experiment Station and elsewhere. On good coastal clay soil its rate of growth is comparable with that of Glenshiel 1 during the early period of its life.

P.B. 25, 86 and Tj. 1 in that order are generally the most vigorous clones in the early years, but P.B. 86 does not maintain this same vigour after the second or third year.

In one experiment on alluvial clay soil, B.D. 5 is still the most vigorous clone at 18 months old, although probably not significantly better than P.B. 86. Areas budded in 1938 are now in the stage of branch formation when interesting differences in habit are to be observed which influence markedly their subsequent rate of growth and the time taken to reach maturity. Amongst the commoner late-branching or sparsely-branched clones are B.D. 5, Glenshiel 1, and Pilmoor D. 65.

METHODS OF PLANTING

The 73-acre experiment laid down to compare the efficiency of stumped buddings, budded stumps, and budding in the field on seeds sown at stake and on seedling stumps is now making good progress, but the seed-at-stake plots are not yet sufficiently well grown to be budded. Growth measurements at this stage would not therefore give information of value. So far the budded stumps are more uniform than the stumped buddings and appear to be making more rapid growth.

CATCH CROP EXPERIMENT

The site chosen for this experiment is not ideal for the purpose, and one section of it has proved to be too poorly drained to

support good crops of either derris or pineapples. Where the soil is more friable the derris has done well and is now forming a very satisfactory soil cover. The pineapples, even under the best conditions of the experiment, have not covered the soil quickly enough, and are clearly unsuited as a catch-crop for stiff clay soils. Tapioca grew so vigorously that after 12-14 months the retardation of the rubber was very marked and the crop was harvested. It is considered that a single crop of tapioca might profitably be interplanted in young rubber areas so long as there is a regular market for the roots within easy reach of the estate.

PESTS AND DISEASES

Now that the potential danger from rats and other vermin to young rubber plants in new clearings is more widely recognised, efforts to meet it have improved and losses from such causes have been appreciably fewer in the 1938 clearings than in those opened previously. Various forms of guards and poisons have been used successfully, and planting with well-grown basket plants appears to have distinct advantages over seed sown at stake in all except the most serious attacks. Although the severity of the damage done by vermin will no doubt vary seasonally and according to the district, there seems no reason to modify our views regarding the amount of clearing desirable provided due precautions are taken beforehand to minimise losses.

The incidence of root disease (*Fomes lignosus*) has appeared as a serious factor in some areas. Its early discovery and treatment are being carried out on recognised commercial lines, although in certain cases this involves considerable interference with experimental treatments. Records of trees treated and eradicated are being kept plot by plot with the dual purpose of noting all departures from uniform treatment (which applies to all operations) and providing information which may be of future value to the Pathologists.

We desire once again to record our thanks to Managers and their Assistants for their active co-operation in the conduct of these experiments.

VIII. Advisory Work

CORRESPONDENCE

An analysis of the correspondence dealt with by this Division appears as an Appendix to the Director's report.

Although there is a big reduction in the number of letters despatched correspondence in connection with Experimental Plant-

ing on Estates still remains the biggest single item, followed by general planting enquiries and the choice of clones for new planting and replanting. The extensive survey which is being made of the yields of budded rubber in commercial tapping is reflected in the big increase in correspondence under this heading.

Four advisory circulars were issued during the year:

August	1939	No. 4.	Notes on Budgrafting
"	"	No. 5.	Notes on Clones
"	"	No. 6.	The Description and Layout of Seed Gardens
December	"	No. 10.	Suggestions for the Establishment of Leguminous Creepers under mature rubber trees (in collaboration with the Soils and Pathological Divisions).

Numbers 4 and 5 were revised editions of circulars previously issued.

IDENTIFICATION OF CLONES

A notice appeared in the March number of the *R.R.I. Planters' Bulletin* stating that the Institute was prepared to send skilled budding mandors to estates to check the identity of material to be used as budwood. There has been a considerable demand for the services of these mandors and 72 visits to Estates were paid for this purpose.

ESTATE VISITS

A summary of the visits made by members of the graduate staff is presented below.

Members of Staff	Nature of Visit				Total
	General Advisory	Research			
		Experi-ment Station	Estates	Experi-mental Planting on Estates	
C. C. T. Sharp -	5	52	1	3	61
E. R. Guest -	4	27	37	1	69
E. D. C. Baptist -	6	43	10	8	67
N. Wright -	34	4	1	43	82
K. N. Kaimal -	5	31	26	1	63
T. V. Vaidyanathan	1	119	—	—	120
Totals -	55	276	75	56	462

INTERVIEWS AND VISITORS

One hundred and fourteen visitors were received during the year. Of these ninety two were seeking advice on the choice of planting material and general planting subjects and twenty-two came to discuss matters in connection with experimental planting on estates.

LECTURES

The following lectures were given:

<i>Venue and Date</i>	<i>Subject</i>	<i>Lecturer</i>
Klang—I.S.P. 17th Jan., 1939	Tapping Systems	E. R. Guest
Kuala Lumpur—D.P.A. 11th April, 1939	Problems of Stock Selection for Budding of Hevea	E. D. C. Baptist
Batang Berjuntai—The Estate Asiatic Staffs' Association 15th April, 1939	The Bark Structure of the Rubber Tree	K. N. Kaimal
Klang—D.P.A. 17th April, 1939	Tapping Systems	E. R. Guest
Rantau—I.S.P. 20th April, 1939	Problems of Current Interest on Estates	N. Wright
Sungei Siput—E.A.S.A. 29th April, 1939	The Choice of Hevea Planting Material	N. Wright
Ipoh—D.P.A. 26th May, 1939	The Performance of Budded Trees of Proved Clones	E. R. Guest
Batu Anam and North Johore—I.S.P. 3rd June, 1939	The Performance of Budded Trees of Proved Clones	E. R. Guest
Kuala Selangor—I.S.P. 4th July, 1939	The Performance of Budded Trees of Proved Clones	E. R. Guest
Teluk Anson and Lower Perak—I.S.P. 18th August, 1939	Problems of Current Interest on Estates	N. Wright
Tanjong Malim—Ulu Selangor and Tanjong Malim—I.S.P. 22nd August, 1939	The Choice of Hevea Planting Material	C. C. T. Sharp
Conference of A.R.Is. at the Institute 19th Sept., 1939	Problem of Stock Selection for Budding of Hevea	E. D. C. Baptist
Ipoh—I.S.P. 27th Sept., 1939	Problem of Stock Selection for Budding of Hevea	E. D. C. Baptist
Malay Peninsular Agricultural Association 28th Sept., 1939	Problem of Stock Selection for Budding of Hevea	E. D. C. Baptist
Kelantan—P.A. 28th Sept., 1939	Performance of Budded Trees of Hevea	N. Wright
Banting and Kuala Langat—D.P.A. 25th Oct., 1939	The Choice of Hevea Planting Material	C. C. T. Sharp

TOURS

The following tours of visits were made by members of the staff of the Division during the year:

In Pahang by Mr. Wright	- -	January	-	3	days
.. Negri Sembilan by Mr. Wright	-	April	-	5	„
.. Perak and Kedah by Mr. Wright		May	-	4	„
.. Negri Sembilan by Mr. Guest	-	May	-	5	„
.. Johore by Mr. Wright	- -	June	-	6	„
.. Perak by Mr. Wright	- -	August	-	4	„
.. Pahang by Mr. Wright	- -	August	-	3	„
.. Kelantan by Mr. Wright	- -	September	-	3	„
.. Province Wellesley by Dr. Baptist		September	-	3	„
.. Negri Sembilan by Mr. Wright	-	November	-	3	„

Mr. Guest paid a short visit to the Experiment Station and Laboratories of the Rubber Research Scheme while on local leave in Ceylon during February, and Mr. Sharp to the Proefstation, West-Java in June.

PUBLICATIONS

Plant Hormones

E. D. C. Baptist, *J.R.R.I.M.* **9** (1939) 17

Palm Oil Diluent for Tar Oil Fungicides and its effects on Bark Renewal in Hevea

F. Beeley and E. D. C. Baptist, *J.R.R.I.M.* **9** (1939) 40

Recommendations for the Choice of Planting Material

C. E. T. Mann, *J.R.R.I.M.* **9** (1939) 79

The International Notation for Tapping Systems and its use in the Tabulation of Yield Records *

Evan Guest, *J.R.R.I.M.* Communication **239** p. 142—163

A Standard International Notation for Systems of Tapping Hevea *

Evan Guest, *J.R.R.I.M.* Communication **240** p. 164—170

Tapping Systems

C. C. T. Sharp and E. R. Guest *The Planter* January 1939

C. C. T. SHARP

Ag. Head of Botanical Division

Kuala Lumpur,

July, 1940.

* Since revised. See Communications 246 and 247 (1940).

ANNUAL REPORT

BOTANICAL DIVISION

INDEX

	Page
Acting Head of Division	83
Advisory Work:	152
Circulars, Advisory	153
Correspondence	152
Identification of clones	153
Interviews and visitors	154
Lectures	154
Publications	155
Tours	155
Visits to estates	153
Anatomical Investigations	145
Bark characters and yield	145
Bark renewal:	
Density of planting, effect	98
Stimulation by growth substance	143
Budgrafted trees:	
Direction of tapping, effect on yield	130
Growth and yields	96
Height of tapping and yields	127
Stimulation of callus growth on stocks	144
Summary of yields at R.R.I. Experiment Station	95
Tapping experiments	105
„ systems	108
Yields from commercial tapping	99
Catch-crop experiment	151
Circulars, Advisory	153
Clonal seeds:	
Stocks for budding	87
Trials on estates	150
Clones, identification	153
Clone trials in field experiments	151
Correspondence	152
Cover-plant seeds, germination	147
Cuttings, propagation	83
Density-of-planting experiment	97
Diseases	152
Ecological studies:	146
Germination of cover-plant seeds	147
Eradicating jungle trees by poisoning	147
Experiments on estates	147
Field Experiments:	
Budding successes	149
Catch-cropping	151

Clonal-seed trials	...	...	...	...	...	150
Clone trials	...	...	...	...	...	151
Methods of planting	...	...	...	...	...	151
On estates	...	...	...	...	...	148
On R.R.I. Experiment Station	...	...	...	...	...	148
Pests and diseases	...	...	...	...	...	152
Stock experiments	...	...	...	...	...	151
Weather conditions	...	...	...	...	...	149
Growth-promoting substances	...	...	...	...	...	84
Hand pollination	...	...	...	...	...	132
Interviews	...	...	...	...	...	154
Jungle trees, eradication by poisoning	...	...	...	...	...	147
Lectures	...	...	...	...	...	154
Manuring						
Effect on tapping systems, budded trees	...	...	...	...	...	124
" " " " seedling trees	...	...	...	...	...	101
Nutrition; pot-culture experiments	...	...	...	...	...	141
Pests	...	...	...	...	...	152
Physiological investigations:	...	...	...	...	...	141
Anatomic investigations	...	...	...	...	...	145
Bark renewal, stimulation	...	...	...	...	...	143
Nutrition; pot-culture experiments	...	...	...	...	...	141
Seed; treatment with growth substances	...	...	...	...	...	141
Stimulation of callus growth on stocks of budded trees	...	...	...	...	...	144
Planting:						
Densities	...	...	...	...	...	97
Methods	...	...	...	...	...	151
Pollination by hand:	...	...	...	...	...	132
Legitimate seedling families obtained	...	...	...	...	...	133
Successes, large-scale methods	...	...	...	...	...	133
Yields from 1928—1931 series	...	...	...	...	...	135
Pot-culture experiments	...	...	...	...	...	141
Propagation, vegetative	...	...	...	...	...	83
Propagation of stocks:	...	...	...	...	...	83
Cuttings	...	...	...	...	...	83
Growth-promoting substances	...	...	...	...	...	84
Root pruning	...	...	...	...	...	84
"Stump" plants	...	...	...	...	...	83
"Twins" plant experiments	...	...	...	...	...	86
Publications	...	...	...	...	...	155
Root pruning	...	...	...	...	...	84
Seed, treatment with growth substances	...	...	...	...	...	144
Seedlings from Isolated Seed Gardens	...	...	...	...	...	138
Seedling root systems, study	...	...	...	...	...	86

	Page
Selection and Breeding:	130
Clone collection	131
Clones from 1937 crosses	136
Hand pollination	132
New clones on estates	132
" " from estate mother-trees	130
" " from legitimate seedlings	136
Yields from illegitimate seedlings of high-yielding clones ...	136
"Slaughter" tapping	121
Stock experiments	151
Stocks for budding	87
Stock-scion relationship in buddings:	86
Clonal seedlings as stocks for budding	87
Influence of scion on yield of stock	93
Seedling root systems, study	86
"Stump" plants	84
Tapping Investigations:	99
Budded trees, experiments on	105
Direction of tapping, effect on yield of budded trees	130
Height of tapping and yield	104
International tapping notation	100
Seedling trees, experiments on	100
Single-task tapping experiments	116
"Slaughter" tapping	121
Tapping systems and manuring	101
Tapping systems on various clones	108
Test-tapping	140
Tapping notation, international	100
Test-tapping	140
Tours	155
"Twin" plants experiments:	86
Girths and yields of budded and unbudded "twins" Series 1 ...	89
Girth measurements—Series 1	90
Girth of budded and unbudded members of twin seedlings— Series 3	91
Growth and yield compared—Series 1 and 2	89
Yields:	
Budded rubber in commercial tapping	99
Buddings and illegitimate clonal seedlings on stocks of some families	87
Budded and unbudded "twins"—Series 1	89
Clones from 1928—1931 series of crosses	137
Illegitimate clonal seedlings from R.R.I. Experiment Station ...	138
Illegitimate seedlings of high-yielding clones	136
Influence of scion on stock	93
Records of budded trees at R.R.I. Experiment Station	95
Tjikadoe Isolated Seed Garden seedlings, summary	139
Yielding qualities of seedlings, determination	140
Yields from 1928—1931 series of hand pollinations, Seedlings ...	135
Vegetative propagation and planting methods	83
Visits, Advisory	153
Visitors	154

ANNUAL REPORT *

PATHOLOGICAL DIVISION

STAFF

Mr. Napper proceeded on long leave to Europe on March 24th returning to duty on November 29th. During that period Mr. Beeley remained in sole charge of all work on diseases and pests of the rubber tree and cover plants.

During the past few years entomological problems in rubber agriculture have assumed greater importance than heretofore. An entomologist, Mr. L. D. E. F. Vesey-Fitzgerald, has now been appointed to investigate and to advise on such problems. Mr. Vesey-Fitzgerald assumed duty on 17th November. In the present report, however, the various sections of entomological nature have been drafted by the officers who have been responsible for the work before the Entomologist's arrival.

Mr. K. P. John, B.A. (Madras), Assistant Pathologist, was on duty throughout the year and it is pleasing to record our appreciation of his valuable assistance in the diagnostic, cultural and routine work of the Division.

Mr. H. C. Chuan, the Institute's Artist and Photographer, whose services are in great demand by all Divisions of the Institute, was on duty throughout the year. We again record our appreciation of the assistance given by the Asiatic Staff both at the laboratories and on the Experiment Station during the year and of the assistance so kindly given to us by those estate managers and staffs who are carrying out field experiments for us.

As in previous years we are grateful to the Government Entomologists who have rendered every assistance to us in identifying insects and have freely advised us on entomological problems in the field. It is hoped that similar co-operation will continue in the future.

GENERAL REMARKS ON PROGRESS OF RESEARCH

With only one European officer in the Division for some 8 months of the year comparatively little time has been available for detailed research but considerable progress has been made in several items of the programme of work for the year. Chief among these are the field experiments: on root disease control reported upon below by Mr. Napper; on the ecology, life history and, later in the year, on chemical control of the cockchafer pest; on the bacteriology of the nodule organisms of leguminous cover

* An index follows page 195.

plants and the supply and multiplication of cultures on estates; and on the bacteriology and preservation of latex.

The abnormally dry weather throughout the year prevented continuation of researches on *Oidium Heveae*, on Mouldy Rot and Phytophthora diseases, and on the field tests of fungicides for control of diseases of the tapping panel.

Work on termites has been confined to the testing of four routine methods of treatment on the Experiment Station, but ecological studies recommenced on the arrival of the Entomologist towards the end of the year.

Further work on rat baits with the co-operation of the Institute for Medical Research was completed and a printed circular No. 7 issued in August. A brochure on the work carried out by Dr. Paranjothy was also issued by the Institute for Medical Research early in the year.

Root-Disease Investigations (Mr. Napper)

Control of root disease in connection with replanting continued to be the most important problem studied under this heading.

Further extensive replantings were undertaken during the year, and interest in the question of eradication during the process of felling and clearing areas of old rubber trees was fully maintained. In addition, large areas of the replantings established during the first restriction period reached the age at which root disease becomes active again in the new stand, and interest began to be focussed on a new aspect of the problem, viz. the control of root disease in young replanted areas.

CONTROL IN YOUNG REPLANTED AREAS

Observations in these areas gave general support to the inference drawn in 1938 from a consideration of the preliminary results from Replanting Experiment B.K.I.* (see Annual Report for 1938, p. 118).

Broadly speaking infections in young replanted clearings fall into two classes, viz:—

(a) infections occurring *within* the boundaries of areas which were known to be infected with root disease in the original stand

(b) infections occurring *outside* the boundaries of the old root-disease patches, i.e. in areas where the original stand appeared to be healthy at the time of felling.

Infections of class (a) are caused by the parasite responsible for the corresponding disease patch in the original stand, and their frequency varies inversely with the extent to which digging and root removal were carried out in these patches before planting.

* A key to the localities of Experimental Centres is on p. 195.

Infections of class (b) are caused by *Fomes lignosus*, and their frequency (referring here particularly to inland soils) varies inversely with the extent to which the root systems of the healthy trees were removed when preparing the clearing for replanting.

From the point of view of control in young replanted stands there is fortunately no need to separate these two classes of infections. Both types yield equally well to the standard treatment, based on periodic tree-to-tree collar inspection, which has been devised for use in young plantations, and the two problems can therefore be dealt with concurrently.

Experience during the past year has shown, however, that in areas where problem (b) is severe, care must be taken in putting treatment into practice if unnecessarily heavy expenditure is to be avoided. In such areas the sources of infection are known to be many and widespread, and it is tempting to extend the scope of inspection by examining the ground cover, and any roots of the old stand which have been exposed by soil erosion, or during the cutting of drains, terraces, and so on, with the object of detecting these sources as quickly as possible and effecting their early removal. Experience has shown, however, that this temptation should be resisted. Many of the sources are small, and when lying at a distance from the planting holes they rot away naturally before being reached by the root systems of neighbouring trees. It is more economical therefore to confine inspection and treatment to the rubber trees. In this way it can be ensured that expenditure on eradication is restricted to the removal of *functional* sources of infection, those which are of no potential danger to the trees being allowed to decay naturally *in situ*.

An exception to the above generalization should be made in areas carrying bush covers of a susceptible type (e.g. *Tephrosia* or *Crotalaria* spp.). As compared with the root systems of creepers and herbaceous plants, the "stumps" of bushes are massive, and, when infected with root disease, constitute sources of infection which cannot be ignored. In areas carrying susceptible bush-covers, inspection and treatment of infected rubber trees should therefore be supplemented by the removal of dead bushes. Collar inspection of the bushes to detect early cases of root infection is not considered to be an economic proposition.

Experience during the year also showed the necessity for keeping strictly to the standard recommendations when carrying out treatment on infected trees. The recommendations direct that the surface mycelium of the parasite concerned should be followed *outwards* from the collars of the trees to the limits of spread of infection. This precaution ensures that only infected roots are exposed, and that cost and soil disturbance are reduced to a



Typical Root-Disease Patches.

PLATE No. III.



Aerial View of Root-Disease Patches.

TABLE 1

Experiment B.K.I. Incidence of root-disease infection up to the end of the second year after planting.
Data arranged to compare the incidence under the different treatments.

Treat- ments	<i>Fomes lignosus</i>			<i>Canoderma pseudoferreum</i>			<i>Fomes nominus</i>			Unidentified parasites			Totals		
	R	B	T	R	B	T	R	B	T	R	B	T	R	B	T
A	31	8	39	15	26	41	4	17	21	3	1	4	53	56	105
B	55	19	74	21	50	71	3	35	38	6	14	20	85	118	203
C	72	12	84	9	38	47	7	40	47	2	16	18	90	106	196
D	102	11	113	6	27	33	3	30	33	1	8	9	112	76	188
E	96	27	126	12	30	42	6	33	39	2	13	15	116	103	219
F	49	17	66	22	91	113	5	28	33	1	5	4	77	139	216
Totals	405	94	499	85	262	347	28	183	211	15	55	70	533	594	1127

R = Nos. of infected rubber trees (including both dead and partially infected trees).

B = Nos. of groups of bushes killed by root disease, excluding those associated with infected rubber trees.

T = R + B.

For details of treatments see Annual Report of Rubber Research Institute for 1937, p. 131.

minimum. A method observed on many estates, however, was to dig over a patch of arbitrary size around each infected tree, commencing work at a distance from the tree and working towards it. This method is not to be recommended. It increases the cost of treatment, often very considerably, without increasing its efficiency, and results in unnecessary damage to the healthy portions of the root system. Even where dead trees are being removed it is more satisfactory to work outwards from the tree, starting on a line passing through the bole, and digging first in one direction and then in the other to the limit of spread of infection.

REPLANTING EXPERIMENTS

Experiment B.K.I. Three further rounds of tree-to-tree collar inspection and treatment were carried out in this experiment during 1939, the results to date being summarized in Tables I to V.

Table I (p. 159) shows the incidence of the various root diseases under the several treatments since the time of planting, separate figures being given for rubber trees and bush-cover plants. It should be clearly understood what these figures represent. For rubber trees they are the sums of all infected trees discovered at the various rounds of inspection in both bush-cover and creeping areas, and include dead and partially affected trees. For bush-cover plants they refer solely to the strips under bush-covers, and represent the total numbers of *groups* of bushes killed by root parasites, excluding those groups associated with infected rubber trees. No collar inspection of the bushes has been undertaken, so that the figures for bushes do not include partial infections which have not yet become detectable by their effects on the foliage.

When comparing treatments, the data for bushes and rubber trees may be bulked together. This is advantageous, since the figures for bushes are high, and by swelling the totals they permit more accurate comparisons between the treatments. When comparing the different diseases, however, data for bushes should be excluded, since the ratio of dead to living infected bushes varies widely from parasite to parasite (see Annual Report for 1938, pp. 119-120) and the order of merit based on figures for dead bushes (which are the only figures available) is unlikely to bear any useful relation to the true order based on total infections.

With regard to incidence of infection under the different treatments, a comparison between Table I and Table II on p. 117 of Annual Report for 1938 shows that the treatments maintained the same relative positions throughout the year. The incidence of *Canoderma pseudoferreum* continued to vary inversely with the

TABLE II

Experiment B.K.I. Incidence of root-disease infection to the end of the second year after planting. Data arranged to show trend of incidence from round to round, and to compare incidence under creeping covers and bush covers respectively

Type of infection		Nos. of cases found during				
		1st round	2nd round	3rd round	4th round	Total
<i>Fomes lignosus</i>	(1)	61	84	52	41	238
	(2)	43	57	37	30	167
	(1) + (2)	104	141	89	71	405
	(3)	13	19	15	47	94
	(1) + (2) + (3)	117	160	104	118	499
<i>Ganoderma pseudoferreum</i>	(1)	3	17	11	11	42
	(2)	6	11	13	13	43
	(1) + (2)	9	28	24	24	85
	(3)	114	79	45	24	262
	(1) + (2) + (3)	123	107	69	48	347
<i>Fomes noxius</i>	(1)	6	2	2	7	17
	(2)	2	3	3	3	11
	(1) + (2)	8	5	5	10	28
	(3)	79	56	30	18	183
	(1) + (2) + (3)	87	61	35	28	211
Unidentified parasites	(1)	3	2	1	0	6
	(2)	5	3	0	1	9
	(1) + (2)	8	5	1	1	15
	(3)	18	14	13	10	55
	(1) + (2) + (3)	26	19	14	11	70
Totals	(1)	73	105	66	59	303
	(2)	56	74	53	47	23
	(1) + (2)	129	179	119	106	533
	(3)	244	168	103	99	594
	(1) + (2) + (3)	353	347	222	205	1127

- (1) = Rubber trees infected with root disease in the creeping-cover areas.
 (2) = Rubber trees infected with root disease in the bush-cover areas.
 (3) = Groups of bushes killed by root disease, excluding those associated with infected rubber trees.

amount of digging carried out before planting in the old root-disease patches, and the incidence of *Fomes lignosus* inversely with the amount of digging before planting in apparently healthy areas of the previous stand (see Annual Report for 1938, pp. 118-119).

Agreement with the above generalization was remarkably close. In the case of *Ganoderma pseudoferreum* the incidence of infection was lowest in treatments A, C, D and E, where the sites of diseased trees were dug deeply before planting; highest in F where no digging or root removal of any kind was undertaken; and intermediate in B which received partial eradication to a depth of 10 inches. In the case of *Fomes lignosus* infection was lowest in A, where the whole area was dug over to a depth of 18 inches before planting; highest in D and E where the boles of the healthy trees were removed but the laterals were allowed to decay *in situ*; and intermediate in B and C where the healthy areas were dug over to a depth of 10 inches before planting.

As in the previous year the only inconsistency was the incidence of *Fomes lignosus* under treatment F. Instead of being the highest in the experiment the incidence of *Fomes lignosus* under this treatment was only half the incidence under D and E, and even slightly less than the incidence under B and C. There can no longer be any doubt that this persistent deviation from the trend observed in the other treatments is due to the fact that the stumps of the trees in treatment F were injected with sodium arsenite, and that this treatment had a marked effect in preventing the spread of *Fomes lignosus* in the roots of the healthy trees during the post-felling susceptible period. It is not possible yet to say whether stump injection with sodium arsenite will prove more economical in the long run than the methods adopted for dealing with the root systems of healthy trees in treatments B, C, D and E. Where infection with *Fomes lignosus* does occur in F it is more expensive to deal with, and the higher cost per point treated may more than outweigh the benefit derived from a reduction in incidence of infection. Information on this point will be obtained in future rounds of treatment by keeping separate costs records for the different root diseases.

It should be emphasized that the foregoing remarks apply solely to treatment F as a method of dealing with the root systems of healthy trees. As a method of dealing with the roots of infected trees this treatment (as was expected) has proved highly inefficient, the incidence of *Ganoderma pseudoferreum* in the F plots being two to three times as great as the incidence in treatments A, C, D and E, and half as heavy again as in B, the next most inefficient treatment.

Table II presents the same data as Table I rearranged to show the incidence of infection at the different rounds of treatment, and details of the distribution of infection between the bush-cover and creeping-cover areas.

With regard to the incidence at different rounds of treatment, it is interesting to note the gradual decline of the attack after the second, and in certain cases after the first round. This indicates that treatment has had a beneficial effect, since the peak of the attack would not be expected, in the absence of treatment, until late in the second or in the third year.

With regard to comparative incidences of infection in bush-cover and creeping-cover areas, Table II shows that, taking all root diseases together, the incidence of infection on the rubber trees has been 30 per cent higher in the creeping-cover than in the bush-cover areas. Examination of the data for the individual diseases shows that this difference is determined by the data for *Fomes lignosus*. In the case of *Ganoderma pseudoferreum* infections in the two types of area have been approximately equal, while the figures for *Fomes noxius* and the unidentified parasites are too small to be significant or to influence the general result. Considering incidence of infection on the rubber trees alone the advantage therefore lies with the bush-covers. This advantage, however, is outweighed by the fact that in the bush-cover areas the bushes themselves suffer heavily from root-disease attack, and where they are killed require considerable expenditure on removal and replacement. In the case of *Fomes lignosus* the ratio of dead bush-groups to infected rubber trees is comparatively small (only 1 to 4); for the other parasites, however, it is large (being as high as 6.5 to 1 in the case of *Fomes noxius*) and taking all root diseases together dead bush-groups represent more than one half the total number of infections.

In addition to carrying dead bush-groups, to a sum of one half the total number of infections in the experimental areas, the bush-cover strips also carry their quota of infected rubber trees. The difference between the total amounts of control work to be done in the bush-cover and creeping-cover areas respectively is therefore very considerable. Reference to Table II shows that up to the end of the second year the number of infected points treated in the creeping-cover areas was 303 (all rubber trees), while in the bush-cover areas the figures were 230 rubber trees plus 594 bush-groups, making a total of 824 points treated. Relative costs of treatment under the two types of ground cover are given in Table III.

TABLE III

Experiment B.K.I. Comparative costs in dollars of Root-Disease Control in Creeping-cover and Bush-cover Areas

Round	Cost in Creeping-Cover Areas (Rubber Trees only)	Cost in Bush-Cover Areas		
		Rubber Trees	Bushes	Total
2nd	185.49	130.73	134.25	264.98
3rd	92.70	55.13	89.33	144.46
4th	131.25	89.50	100.25	189.78
Totals	409.44	275.36	323.83	599.19

Comparative figures are not available for the 1st round.

These figures show that up to the present the cost of treatment in the bush-cover areas has been consistently 50 per cent higher than the cost of treatment in the creeping-cover areas. That the difference in cost between the two types of area is proportionately smaller than the difference in incidence of infection is due to the fact that a large percentage of the infected bush-groups are small, local infections, caused by *Fomes noxius* or unidentified parasites, which are much less expensive to deal with than infections caused by the major root-parasites *F. lignosus* and *Ganoderma pseudoferreum*. Among the rubber trees, infection by the major parasites amounted to 92 per cent of the total; among the bush-covers, however, the figure was only 31 per cent.

TABLE IV

Experiment B.K.I. Costs of root-disease treatment year by year up to the end of the second year (in dollars per acre)

Treatment	Preparation	1st year	2nd year	Total to date
A	75.35	1.51	6.51	83.37
B	43.43	4.30	11.80	59.52
C	54.76	2.65	10.81	68.22
D	48.21	3.91	15.11	67.23
E	26.89	3.17	12.97	43.03
F	10.31	9.87	25.37	45.55
Means	43.16	4.23	13.76	61.15

The lower incidence of infection on the rubber trees in the bush-cover, as compared with the creeping-cover, areas was unexpected, and it will be interesting to see whether this tendency persists in future rounds of treatment, and whether it is also observed in Experiment H.2 on coastal soil. The higher cost of treatment in the bush-cover areas was, however, in accordance with expectation, and supports our contention that the planting of leguminous bush-covers (in preference to leguminous creepers) in root-diseased areas, for the sole purpose of "indicating" sources of root-disease infection, is an economically unsound policy.

TABLE V

Experiment B.K.I. Costs of root-disease treatment round by round since planting (in dollars per acre)

Rounds	Treatments						Means
	A	B	C	D	E	F	
1st	1.51	4.30	2.65	3.91	3.17	9.87	4.23
2nd	2.70	5.88	4.04	7.99	4.71	10.94	6.04
3rd	1.71	1.89	3.45	2.41	3.95	6.43	3.31
4th	2.10	4.03	3.32	4.71	4.31	8.01	4.41
Totals	8.02	16.10	13.46	19.02	16.02	35.24	17.99

For details of treatments see Annual Report of the Rubber Research Institute for 1937, p.131.

Table IV shows the costs of the various treatments year by year since the commencement of the experiment. In studying these figures the interesting points to observe are:—

- (i) That A is still the most expensive treatment, although B, C and D are gradually catching up with it.
- (ii) That D has already caught up with C.
- (iii) That F has already caught up with E.
- (iv) That E, up to the end of the second year, has proved to be the most economical treatment.

With reference to (i), there is now little difference in cost between treatment A on the one hand, and treatments C and D

on the other. This suggests that, in the area under experiment, the attempt to economise in C and D by restricting digging to the areas of the disease patches has scarcely been justified. In comparing these treatments, however, two facts should be borne in mind. In the first place the treatment of disease patches was deeper and more thorough in C and D than in A, where belated attacks are likely to occur as the roots of the new stand penetrate more deeply into the soil. In the second place the incidence of root disease in the experimental area before planting was exceptionally high. In the average replanting, where the ratio of diseased to healthy areas is only of the order of one third or one quarter of the ratio obtaining in the present case, the difference in cost between A and C or D is very considerable (*c.f.* costs of treatments A and D in Experiment H. 1 as given in Table VI below).

With reference to (ii), the fact that C and D are now approximately equal suggest that the cost of digging over the healthy areas in C to a depth of 9-10 inches has been roughly balanced in D by the cost of dealing with the higher incidence of *Fomes lignosus* incurred in this treatment as a result of the absence of digging in the healthy areas. It will be interesting to see whether this balance is maintained in the future.

With reference to (iii), it is interesting to observe that the cost of digging out the roots of infected trees when clearing the original stand has been justified as early as the end of the second year after planting. There is every indication that the cost of F will rise sharply again during 1940, and that this treatment will eventually prove one of the most expensive in the experiment. These remarks apply solely to F as a method of dealing with infected trees, where it amounts in practice to an absence of treatment. Treatment F as method of dealing with healthy trees is more promising, and was discussed earlier in this report.

With reference to (iv), the favourable results obtained with E suggest that digging of the open central areas of the root-disease patches, as carried out in treatments C and D, may not be justified economically. It is too early yet to form a final opinion on this point, and for the present a light exploratory digging in the central areas is still recommended.*

Table V shows details of the costs of the several rounds of treatment carried out since planting. These figures indicate the same tendency for the attack to decrease in intensity after the second round of treatment as was shown by the incidence figures

* For further information on this point see Pathological Division Advisory Leaflet No. 3 (1940), February 1940.

given in Table II. Costs for the fourth round are above those for the third, but this is because the third round was carried out during exceptionally dry weather, and much of the heavier digging had to be deferred until the next round.

Experiment H.I. Four additional rounds of treatment were carried out in this experiment during 1939, the results to date being summarized in Table VI.

TABLE VI

Experiment H.I. Incidence of Root Disease and costs of treatment year by year up to the end of the second year after planting

Treatment	Nos. of Infections			Costs of Treatment (dollars per acre)			
	1st year	2nd year	Totals	Prepa- ration	1st year	2nd year	Total to date
A	32	13	46	73.69	1.10	2.29	77.08
B	31	9	40	37.19	1.44	1.93	40.56
C	58	35	93	17.31	(a) 2.61	(a) 5.68	
					(b) 7.51	(b) 12.59	
					(c) 10.12	(c) 18.27	(c) 45.70
D	16	17	33	11.43	1.58	3.96	16.97
Totals	138	74	212		(d) 1.68	(d) 3.46	
Means				34.91	(e) 3.56	(e) 6.61	(e) 45.08

(a) = Cost excluding cost of strip-digging

(b) = Cost of strip-digging

(c) = (a) + (b), i.e. total cost.

(d) = Mean cost per acre excluding (b)

(e) = Mean cost per acre including (b)

For details of treatments see Annual Report of the Rubber Research Institute for 1937, p.133.

In examining these figures the main points to observe are:—

- (i) The sharp decline in incidence of infection during the second year after planting in treatments A, B and C, the incidence under D remaining constant.
- (ii) The similarity in incidence in between treatments A and B.

- (iii) The continued high incidence in treatment C.
- (iv) The low cost of digging the remaining 10-foot strips in treatment C.
- (v) The low incidence, and very low total cost under treatment D.

With regard to (i), this difference in the trend of infection between dug and undug treatments is in line with previous experience in new clearings, where the peak of infection is always reached more quickly in dug than in undug areas. This is probably because the sources in the dug areas are fragmentary, and therefore come into activity more quickly, and decay more rapidly, than the sources in the undug areas.

With regard to (ii), it is surprising that treatment A has as yet shown no superiority over treatment B. In this connection, however, it should be pointed out that 31 out of the total of 46 cases observed up to the present time in A have occurred within a single plot. It is possible therefore that the figures as they stand give an unfair comparison between these two treatments. A similar irregularity has been observed in treatment C, where 77 out of a total of 93 cases have occurred in two of the four plots under this treatment. Further data are necessary before these irregularities can be properly interpreted.

With regard to (iii), the incidence of infection in treatment C has been consistently above the incidences under the other three treatments at every round of inspection except the fifth, when A and C were equal. Taking the totals to date, C has given twice the incidence under A and B and three times the incidence under D. The apparent magnitude of the differences between C and the other treatments may be due in some measure to the irregularity mentioned above, but plot figures indicate that these differences are nevertheless real. The phenomenon is difficult to explain satisfactorily. As far as the growth of the young trees is concerned treatment C has approximated to treatment A, and it was not expected that there would be any appreciable difference in incidence between these two treatments. It is true that in many instances the trees in C have extended their roots beyond the limits of the dug strips, but this alone will not explain the higher incidence in C, since the conditions in the undug strips were those of treatment D, which has given the lowest incidence of all in the experiment. It may be suggested that the digging in C was less efficient than in A, but this again will not explain the higher incidence in C, since C was certainly dug more deeply than B, and this treatment also has given a lower incidence than C in the experiment. It seems reasonable, therefore, to conclude

that the high incidence in C must have been caused by some special feature of the strip-digging treatment, not present in A or B, which was capable in itself of increasing the incidence of root disease in the strip-dug plots. The only obvious feature of this kind in treatment C was the existence (up to the end of the second year from planting) of boundary faces between dug and undug areas. A possible explanation is that the severed root ends along these faces provided the parasite with an easy means of entry into the network of old rubber roots in the undug strips between the planting rows. This could raise the incidence of infection on the replanted stand: (a) by increasing the incidence of infection on the old rubber roots left unextracted in the dug strips below the level of the 18-inch digging, these roots being connected in most cases with the root-network in the undug areas; (b) by increasing the chance of infection on lateral roots extending beyond the boundaries of the dug strips; and (c) by increasing the amount of infected material accidentally left unextracted as the strips were progressively widened. Up to the present (b) has had no practical effect, since in every case so far treated the point of contact has lain within the limits of the dug areas. The sources have frequently been found, however, to extend into the undug areas in the manner suggested in (a), and there is little doubt that both (a) and (c) have played a part in inducing the high incidence of infection observed in this treatment. No attempt is made here to explain *how* the cut ends of the old rubber roots encouraged the extension of root-disease infection. That they did do so, however, seems highly probable, judging by the data so far obtained in this experiment. A similar effect may explain the high initial incidence of infection in treatments A and B as compared with treatment D, the boundary faces in this case being in a horizontal instead of in a vertical plane.

With regard to (iv) the cost, which worked out at \$12.59 per planted acre, was at a lower rate *per unit area dug* than the figure of \$7.51 per planted acre for the 5-foot strips dug over in 1938, and compared very favourably with the high figure of \$17.31 per planted acre for the original 5-foot strips dug over before planting in 1937. Complete digging over in this treatment, spread over a period of two years, has thus been accomplished for the moderate figure of \$37.14 per acre. Complete digging over to the same depth *before* planting was found in treatment A to cost \$73.69 per acre. The deferred method has therefore resulted in a saving of 50 per cent of the digging cost, at a price, however, of a higher incidence of infection in the replanted stand.

With regard to (v), treatment D continues to compare very favourably with the other three treatments both in incidence of

infection and in cost of treatment. The total incidence to date is still the lowest in the experiment, while the cost is less than half the cost in B and C, and less than one quarter the cost in A. The attack must be expected to extend over a longer period in D than in the other treatments, but the incidence is low, and it is unlikely that future expenditure on control will be high enough to prejudice the present position of this treatment as the most economical in the experiment. It should be pointed out that treatment D is the standard method recommended by this Institute for use in both inland and coastal districts. Tentative explanations of the low incidence of infection to date in this treatment, as compared with treatments A, B and C, are given under (i) and (iii) above.

OTHER REPLANTING EXPERIMENTS

The first rounds of tree-to-tree inspection and treatment were carried out in Experiments H. 2 and L.P. 1 towards the end of the year, but the incidence figures were too low to give any reliable indications and will not be reported here. The first round of treatment in Experiment B.K. 2 will be carried out early in 1940.

ROOT-DISEASE CONTROL IN NEW CLEARINGS

As a result of the partial lifting of the ban on new planting, there was a revival of interest during the year in methods of felling and clearing virgin jungle, and in the effects of such methods on the incidence and control of root disease in the subsequent plantation.

Much useful information was obtained on this subject from the experimental clearings established under the provisions of the 1934-1938 restriction agreement. The most striking fact revealed was the reduced incidence of root disease during the early years after planting in areas *cleared without burning*, as compared with areas burnt off in the usual way. This fact had been suggested by earlier observations, but was confirmed during the year in several independent experiments, and may now be considered established. Up to the end of the third year from planting (which is as far as the present records go) it appears normal to expect at least twice as many root infections in burnt as in unburnt areas, and in one experiment a ratio as high as 5 to 1 was observed. No satisfactory explanation of this phenomenon has yet been advanced. It was thought at first to indicate a delayed attack in the unburnt areas, due to the greater bulk of timber left after clearing in these areas as compared with areas burnt off in the normal way. Recent observations suggest, how-

ever, that this is not the case, but that burning actually *encourages* the spread of root infection among the root systems of the jungle trees during the susceptible period after felling. The matter is under close investigation, and it is hoped that more definite information will be available in the near future.

Observations in experimental new clearings also illustrated the difficulties of early root-disease treatment in areas cleared without a burn, or with only a light "scorch" burn, and emphasized the care which has to be taken in putting the standard recommendations into practice in such areas if uneconomic expenditure is to be avoided. The heavy masses of timber lying between and across the rows of rubber trees make eradication work during the early years a difficult and expensive business, and it was found necessary in many cases to recommend the restriction of digging and root removal to the cleared rentices along the planting rows, diseased roots passing beneath the mass of timber lying between the rows being marked for removal as soon as rotting had progressed far enough to allow the work to be carried out without undue expenditure. Similar deferred eradication was recommended for the larger infected jungle stumps, the laterals being removed in the current round of treatment, but the boles being left to be dealt with later.

As in the case of young replanted areas it was found necessary to stress the importance, when carrying out treatment of infected rubber trees, of following infection *outwards from the collar of the tree* (see p. 158).

LABORATORY EXPERIMENTS

Some interesting experiments were carried out during the year by the Assistant Pathologist, Mr. John, on the use of Baven-damm's "Oxidase" test for distinguishing between different species of wood-rotting fungi in the vegetative stage (see *Journal of Agricultural Research*, Vol. 57, pp. 683-695). A reliable method of this kind would be of very great assistance to us, since it is rarely possible to obtain fructifications of the wood-rotting fungi we are called upon to identify, and identification on mycelial characters alone is a matter of considerable difficulty.

Mr. John's preliminary findings show that on a gallic acid medium the three main root parasites have highly characteristic reactions. This work will be continued.

Diseases of the Tapping Panel (Mr. Beeley)

MOULDY ROT (*Ceratostomella fimbriata*)

Following the absence of monsoon rains in the last few months of 1938 the year 1939 continued dry throughout with only light

rains in the March-May and September-November seasons, and as a consequence the Mouldy Rot fungus, which becomes active only in wet weather, was not much in evidence even in the small-holdings of wet foothill valley regions.

Owing to its freedom from disease the bark renewal during the past two years on many smallholding rubber trees has been greatly improved. On the other hand a considerable number of reports of sunscorch of the recently tapped bark were received from larger estates.

TESTS OF FUNGICIDES IN CONTROL OF MOULDY ROT

Owing to the dry weather and absence of suitably diseased testing grounds it was impossible to carry out tests on the five proprietary and other experimental fungicidal mixtures now awaiting test. We have therefore been unable to advise Government to make any addition to the White List of Fungicides for use in control of Mouldy Rot.

Following upon the work, completed last year, on the use of palm oil as a vehicle for tar oil fungicides, a paper was written and published in the Institute's *Journal* (see p. 194) as a result of which many planting managers have now become interested in the use of palm oil for prevention and cure of disease or sunscorch of the tapping panel and for improvement of bark renewal.

BLACK STRIPE AND PATCH CANKER

As reported last year the situation regarding the *Phytophthora* diseases of rubber trees has not changed, the continued dry weather being totally unsuited to an epidemic spread of diseases of this kind. Practically no records of their occurrence were received. In October and November several cases of *Phytophthora* dieback of seedlings and budshoots were confirmed and shown to be due to a combination of local planting and weather conditions.

SUNSCORCH OF THE TAPPING PANEL

With the continued dry weather attention has been drawn to further evidence of the drying out and sinking of the innermost cortical tissues exposed by tapping. The dark sunken tissues over a band one or more inches wide, extending over the part of the cut facing the morning sun, rapidly die and form large wounds. In some cases a white mould, *Fusarium* sp., appears on the surface and leads to confusion with the mould of true Mouldy Rot. A general circular describing the symptoms of sunscorch

and heat damage with suggestions for its prevention or amelioration was issued towards the end of the year (see p. 194). In addition the circular contained suggestions regarding the prevention of sunscorch of young seedlings and buddings, and treatment of damage to rubber trees caused by leaf fires.

BROWN BAST

The scarcity of reports of this physiological disease of the tapping panel during the year, even in high-yielding budded rubber, is no doubt due to two main factors. Firstly most estate managers are now aware of the correct tapping systems to adopt for a particular clone, or if dry trees occur how to modify the tapping system to avoid further incidence of disease; and secondly the dry weather of the past year has not been conducive to the appearance of Brown Bast, which requires rapid growth and meristematic activity for its development as well as the exhaustion of the latex system, as described in the Annual Report 1938, p. 126 under this heading.

It is, however, of note that the planting of leading clones has in no instance needed to be discouraged on account solely of susceptibility to Brown Bast or other diseases.

Stem and Branch Diseases (Mr. Beeley)

PINK DISEASE (*Corticium salmonicolor*)

Pink disease of either the rubber trees or bush covers has been of comparatively rare occurrence during the year, again owing to the dry weather, and the position cannot be said to have changed appreciably since the last annual report.

DISEASES OF BUDDINGS

Work in connection with diseases of buddings consists chiefly in recording such diseases as are reported to us or discovered in our rounds of visits to estates and the Experiment Station. As previously stated there appears to be revealed no special susceptibility on the part of any individual clone to a particular disease, though some clones show evidence of nutritional deficiencies on some soils while growing vigorously on others and certain clones are able to withstand drought better than others.

Attention is again being drawn to the occurrence of bark bursts on the stem and branches of budded rubber trees. This also seems to be an after effect of drought and is said to occur very frequently in Indo-China during the rapid growth period after the arrival of rain at the end of the long dry period of monsoon winds.

Small longitudinal splits occur in the bark from which long streams of latex exude; a dozen or more such splits may be present over a one foot length of the stem of a 4-year-old tree. There appears to be no parasitic organisms concerned in producing these symptoms and it is concluded that they are entirely of physiological origin. In time a vigorous callus is established at the edges of the splits which rapidly heal over leaving no serious after-effects. In one case a similar effect had been artificially produced by omitting to remove the label wire on the trunk of the tree. After a period during which the bark and wood grew round and embedded the wire subsequent rapid growth caused the bark bursts which appeared only above the constricting wire.

Leaf Diseases (Mr. Beeley)

HEVEA LEAF MILDEW (*Oidium Heveae* Steinmann)

As in previous years the whole of the rubber-growing country west of the main range was inspected during the refoliation period and a report on the incidence of leaf mildew was written, a summary of which follows:—

“The North East monsoon period which normally brings heavy rain throughout the Peninsula during the months of November and December failed to do so at the end of 1938. In consequence an early wintering was to be expected. However, January 1939 proved rather more wet than usual, especially in the central and southern States, and thus caused a two to three weeks delay in wintering. Fortunately, February was an ideal, fine, dry month over the whole country and a severe wintering was induced.

“In the north the trees had almost completely refoliated before any serious, dull weather occurred and thus they practically escaped attack by the mildew fungus. In the central districts and areas at the foot of hills of greater altitude, owing to local climatic conditions the wintering had been delayed sufficiently to favour a mild incidence of disease in the late-wintering trees. Although little serious leaf-fall ensued, first blossom appears to have been very seriously affected.

“Further south, though later, the refoliation proceeded in bright weather and occasional heavy showers without any serious loss by disease, and in general the foliage is well up to normal and in many areas rather better than in previous years.

Sulphur-dusting programmes in various parts of the country were either abandoned as unnecessary or curtailed so that only two or three rounds of dusting were actually carried out. The

frequent, heavy, afternoon showers would considerably reduce the effect of the sulphur dust applied the same morning.

The sudden appearance of the disease within 48 hours of the onset of dull weather adds further support to the theory that the fungus hibernates in the buds of the trees and as these open the hibernating mycelium is able to take advantage of the advent of dull cool humid weather and produces an early crop of conidia which are rapidly broadcast.

The accompanying table, showing the rainfall for the same six districts as given in last year's report, affords an interesting comparison with the weather of previous years, and particularly shows the early drought which ensures a complete, almost simultaneous wintering of all trees in a given area followed by regeneration of a canopy of healthy foliage.

TABLE VII

Rainfall in inches

District		January	February	March	April	May	Total for 5 months
Kuala Lumpur	(Sel.)	13.18	4.59	7.25	7.30	7.17	39.49
Sitiawan	(Pk.)	5.87	5.13	7.86	8.47	12.42	39.75
Port Dickson	(N.S.)	4.44	2.29	3.02	6.02	10.27	26.24
Tampin	(N.S.)	7.95	5.33	6.55	4.98	2.80	27.61
Malacca	(S.S.)	4.75	2.01	2.28	5.29	8.80	23.13
Johore	(J.)	12.76	3.94	17.63	9.68	12.04	56.05

MINOR LEAF DISEASES

There is no change in the position under this heading from that reported last year. A further test of spray fluids was carried out in connection with the lethal effect of chemicals on the foliage and green bark of rubber trees and cover plants, which is reported below.

TABLE VIII

Spray Fluid	Range	Concentration at which burning took place					Cover damaged
		Safe for all tissues	Young leaves	Older leaves	Shoots	Green bark	Old bark
1. "Pysect"	... 1%—7%	1%—4%	5%	7%	5%		5% lightly spotted 6% burned
2. Copper sulphate	... 0.5%—4%	0.5%—1%	2%	2%	2%	3%	2%
3. Lead arsenate	... 0.5%—2.5%						2.5% lightly burned
4. Solar oil : soap emulsion	... 2%—8%		2%	2%	2%	6%	2% light 4% heavy burning
5. Kerosene : soap : lead arsenate	0.5%—2%	0.5%	1%	1.5%	1%		1.5% partly killed
6. Derris : soap mixture	... 1 oz.—5 oz. in 1 gallon	1—2 oz.	4 oz.		3 oz.		3 oz. lightly spotted
7. Kerosene : soap emulsion	... 2%—8%	2%—6%	8%		8%		8%
8. White arsenic	... $\frac{1}{2}$ oz.—1 $\frac{1}{2}$ oz./gln.		$\frac{1}{2}$ oz.	$\frac{1}{2}$ oz.	$\frac{1}{2}$ oz.	1 $\frac{1}{2}$ oz.	1 oz.
9. Sodium arsenite	... $\frac{1}{4}$ oz.—1 oz./gln.		$\frac{1}{4}$ oz.	$\frac{1}{4}$ oz.	$\frac{1}{4}$ oz.	$\frac{1}{4}$ oz.	$\frac{1}{4}$ oz.
10. Liver of sulphur	... 0.5%—2%		0.5%	1%	0.5%		0.5%
11. Bordeaux Mixture	... 5 : 5 : 50	5 : 5 : 50					
12. Barium fluosilicate : talc, applied as a dust	ap- 1 to 1,-- ... 1 to 10 of Talc	1 to 10 of Talc	1 to 5	equal parts	equal parts		1 to 2 of Talc
13. Perchloride of mercury	... 0.5%—2.0%	Less than 0.5%	0.5%	0.5%	5%	1.0%	2.0% safe on brown bark.

PHYTICIDAL CONCENTRATION TESTS OF SPRAY FLUIDS

In view of complaints which are so often made of damage to plant tissues by spray fluids, an experiment was carried out in a closely planted area of young rubber trees with leguminous and indigenous cover plants between the rows. Concentration of spray fluids above and below those normally advised for estate pest control were applied to plots of 30 trees and to the intervening cover, and careful note taken of the damage caused to the new young leaves or budding shoots, to the older whorl of leaves lower down the stem, to the green immature bark of the stem and to the older brown bark. The results shown in the accompanying table are of considerable interest and show the amazing tolerance of the rubber tree to chemical spray fluids, providing that the spraying is done at the correct time, i.e. during the cool hours of the morning and late afternoon. Past experience has taught us that spraying rubber trees during the heat of a sunny, tropical midday may be fatal to young foliage even though water alone is used. Spraying should be sufficiently heavy to cover the leaves evenly and not to cause excessive dripping, otherwise the drip-tip of the leaf is killed and a general withertip of the leaves sets in.

The Cockchafer Pest (Mr. Beeley)

Early in the year Mr. Napper, in co-operation with the Senior Government Entomologist, commenced experimental work on the life history of *Psilopholis vestita* (Sharp) on an estate in Northern Selangor. In March, on Mr. Napper's departure on leave, Mr. Beeley took over the work. With the help of Che Mohamed Yusope, who was kindly seconded temporarily from the Entomological Division of the Department of Agriculture, considerable information regarding the life history and habits of this species of cockchafer was obtained. The main conclusions reached in this Division as a result of this work and observations on other infested areas were as follows:—

Of paramount importance is the indication which these observations have given that the cockchafers are developing entirely within the rubber areas and do not appear to need to return to or have any connection with the jungle at any time in their life cycle, although a small population is maintained in the jungle, and the rubber areas were probably infested from the jungle originally. Even for oviposition the jungle was entirely shunned and densest egg and grub populations were found in the grassy slopes in the rubber areas at considerable distance from the jungle boundary.

The population of cockchafer beetles or grubs in the jungle was very small, being kept down no doubt by insect and animal predators, but is still a potential source of danger to neighbouring rubber areas.

Conditions in the cage experiments with the beetles in captivity were apparently unsatisfactory for successful development and oviposition by the beetles. Further cage experiments with improved conditions, are needed.

Food preferences have been determined to some extent but may not be applicable to all districts.

Little indication of possible economic control by spraying the food plants of the beetles has been obtained. The encouragement of favoured food plants with a view to spraying them with poison is worth further investigation.

Insect parasites other than the scolia wasps have not been observed.

Presumably owing to the dry weather, mortality from the muscardine fungus was extremely low—about 5 per cent—reckoned on grubs, pupae and beetles collected during the whole period of experiment.

Mortality from the wasp parasites was greatest in the mature grubs (60 per cent) and least in the younger grubs and pupae (less than 20 per cent).

No promising methods of control other than by natural parasites and by soil fumigation have been definitely indicated, but the encouragement of favoured host plants, light grasses, etc. as a means of facilitating collection of beetles, as suggested below, or for spraying with poisons is worth investigation.

The collection of some 24,000 pupae, beetles etc. on the estate has had no obvious effect on the repopulation of the soil with young grubs. An estate near Bahau, however, reported that after collection of about 80,000 beetles fewer young grubs appeared to be present in the area. Collection of beetles can be done easily and cheaply, and if done *early and well* may afford a suitable means of control.

The treatment of rubber areas may be undertaken with reasonable hope of success wherever conditions are similar to those at the estate where these observations were made, *viz.* only a low population in the jungle area, as reinfestation from the sparsely infested jungle following successful treatment is thought likely to be slow, and further treatment of the rubber areas should not be necessary for some time.

It has been noted that in some cases the cockchafer grubs are abundant in abandoned areas and in scrub jungle which has been heavily depleted of its marketable timber. In such circum-

stances treatment to give complete eradication of the pest would have to include a wide belt of such land if the neighbouring rubber is to be reasonably assured of a few years' freedom from the pest.

Several lines for further study have been indicated and will be taken up by Mr. Vesey Fitzgerald next year.

A circular letter was sent out to all estates known to have grub-infested areas requesting particulars of the severity of this year's infestation, increase or decrease in area infested and observations on covers and nearby jungle infestation. The information obtained yielded the following interesting figures.

			1939	1938
Total Estates with grubs (all species)	...	...	38	42
Total „ „ <i>Psilopholis</i>	...	...	26	32
Total new cases	...	...	11	12
Pest disappeared (<i>Psilopholis</i> 8)	...	...	12	not recorded
No replies	...	...	3	

Inspection pits (3 ft×3 ft.×1 ft. deep) dug for 1939 survey on various estates and on their jungle boundaries yielded the following data:—

Number of grubs collected from pits	...	...	...	34,126
Number of pits dug in rubber estates	...	...	...	8,116
Average per pit in estates	...	...	...	4.2
Number of pits dug in jungle	...	...	...	826
Number of grubs found in jungle pits	...	...	...	728
Average per pit in jungle	...	...	...	0.9

14 estates report no grubs in jungle.

6 estates report very few grubs in jungle.

4 estates report infestation ranging from 0.5 to 1.0 grub per pit in jungle.

4 estates report infestation with more than 1 grub per pit in jungle.

Infestations have been discovered under all conditions of cultivation: under clean-weeded conditions, under natural covers and under leguminous creeping covers. The lighter soils with fair moisture content under light covers or *Paspalum*-type grasses appear to be most commonly favoured. In jungle the pest favours the scrub type of forest from which the big timber has been removed. The reported disappearance of the pest from 12 estates is of interest and it may be that on the 3 estates from which no replies have been received the pest cannot be found this season. Some estates, however, report considerable increases in the acreage infested this season as compared with last year.

TABLE IX

Cockchafer infestation 1936—1939 (September 30th)

Year	No. of Estates which reported infestation.	Area of Estates		Area of soil infested	
		Acres	% All Malaya	Acres	% All Malaya
(1) <i>All Species</i>					
1936	20	45,846	2.27	1,560	0.07
1937	30	69,605	3.44	2,120	0.10
1938	42	89,103	4.41	3,406	0.17
1939	38	90,865	4.47	2,812	0.14
(2) <i>Psilopholis vestita</i> only					
1936	14	24,834	1.23	1,250	0.06
1937	24	49,152	2.43	1,680	0.08
1938	32	64,344	3.18	2,790	0.14
1939	26	58,905	2.89	2,235	0.11

Throughout the later part of the year soil injection experiments have been carried out on six differently situated estates. It was intended to complete most of the experiments in October or early November but owing to the late arrival of some of the chemicals and to the breakdown of practically all our soil injectors the experiments were not completed until the end of December. However the weather throughout was fairly dry and quite suitable for our purpose.

When sufficient chemical was available experiments were carried out on all or as many of the six estates as possible, and the results given below represent the average kill obtained in a number of experiments in grub-infested soils representing variants of the loams and sticky loam soils usually favoured by the cockchafer grubs. The "Vermorel" soil injectors are designed to give doses of 4 to 9 ml. of fluid per shot, and when possible higher doses were given by increasing the number of shots per point, turning the injector round through a number of degrees after each shot in order to obtain a better distribution of fluid. In some cases however, for application of doses of 1 oz. or more, a 1½ oz. bottle measure was used, the liquid being poured (dibbled) into a

previously made hole which was then sealed. Unless otherwise stated, the spacing of the shots was 18" x 18".

Carbon Bisulphide

Spacing of shots	...	15" x 15"			18" x 18"		
Dose per shot; m.l.	...	3.	5.	6.	4.	6.	8.
Average kill per cent	...	78	87.5	90	54	66	61

50% Carbon Bisulphide emulsion in water;

Dose per shot; m.l.	...	7.5	10	12.5	15	35	(Dibbled)	
Average kill per cent	...	54.5	70.6	76	86	51		

25% Carbon Bisulphide emulsion in water;

Dose per shot; m.l.	...	8	10	16	20	24	30	32	35
Average kill per cent	...	18.5	36	12	50	31	56	74	58

Carbon Bisulphide: Carbon Tetrachloride;

Proportion	...	1 : 1			2 : 1			3 : 1		
Dose per shot; m.l.	...	6	8	10	4	6	8	6	8	10
Average kill per cent	...	33	34	62	38	47.5	77.5	61	75	66

Carbon Bisulphide 1 part: Trichlorethylene 1 part;

Dose per shot; m.l.	...	6			8				
Average kill per cent	...	43.5			28.5				

Carbon Bisulphide 3 parts: Trichlorethylene 1 part;

Dose per shot; m.l.	...	4			6				
Average kill per cent	...	46			56				

Carbon Tetrachloride

Dose per shot; m.l.	...	8			8		10		
Average kill per cent	...	10			20		20		

Tetrachlorethane

Dose per shot; m.l.	...	5			6		7			8
Average kill per cent	...	12			7		9			20

Potassium Sulphocarbonate

Dose per shot; m.l.	...	8			12		16		
Average kill per cent	...	50			68		98		

Potassium Sulphocarbonate: Acid water: Ordinary water

(The acid water used was latex serum, old toddy or dilute vinegar).

Proportions of fluids	...	1 : 1 : 2			1 : 1 : 3		1 : 1 : 4		
Dose per shot (dibbled in) m.l.	...	35			35		35		
Average kill per cent	...	45.5			32		30		

Petrol

Spacing of shots	...	9"x9"	12"x12"	12"x12"	18"x18"	18"x18"
Dose per shot, oz. (dibbled in)	...	2	1½	2	1½	2
Average kill per cent	...	86	34	49	2.5	44

Action rather slow requiring 14 to 28 days for above recorded kills as against a few days for the previously mentioned larvicides.

Methallyl Chloride

Spacing of shots	...	12" x 12"			18" x 18"		
Dose per shot; m.l.	...	3	4	5	3	4	5
Average kill per cent	...	62.5	81	79	35	52.5	36

Methallyl Chloride 33.3% emulsion in water;

Dose per shot; m.l.	...	6	8	10
Average kill per cent	...	17	37	29
<i>Cyanogas (Powder)</i>				<i>Cymag (Powder)</i>
Spacing of shots	...	12" x 12"		12" x 12"
Dose per shot, oz.	...	½	¾	½
Average kill per cent	...	26	44	52

Cyanogas: 10% solution in water.

Spacing of shots,	...	12" x 12"
Dose per shot; m.l.	...	10
Average kill per cent	...	5.5

Calcium Cyanamide (Fertiliser)

Dose per shot, oz.	...	¼	½	¾	1
Average kill per cent after one month	...	13	48	50	100*

From the above it is concluded that the most efficacious soil larvicide is carbon bisulphide or its emulsions. Potassium sulpho-carbonate has given fair results and is worthy of further trial. Methallayl chloride is also efficacious but its cost, as is also the case with carbon bisulphide is prohibitive.

Normally the percentage kill of grubs varies directly with the concentration of the larvicide applied, with the proximity of the points at which it is applied and with the number of grubs per square yard of soil surface. Some exceptions to this general rule have however been encountered and are probably caused by an abnormally low grub-population in the plot or by heavy showers of rain on the day of treatment.

* It should be mentioned that in the 100-per-cent-kill section, though no living grubs were found 13 pupae were discovered and 10 grubs had been killed by wasp parasites. Grubs killed soon after the treatment would probably have decayed and disappeared by the time of inspection one month later. Further work on this promising combined fertiliser and larvicide is indicated.

Termites (Mr. Napper)

The comparative tests of "crater" and "trail-injection" methods of control referred to on p. 133 of the Annual Report for 1938 were continued at the Experiment Station during 1939, and results for two full years are now available for analysis.

The data will be discussed in detail in a separate publication. The following notes and tables indicate the more important conclusions reached.

Table X shows the incidence of infestation and numbers of tree-treatments carried out under the various methods of control during the course of the experiment. It also shows, in column (7), the numbers of planting points which had been attacked before the commencement of the experiment in the areas covered by the different treatments. The latter figures provide a measure of the natural tendency to infestation in these areas, and show, by the fact that they are all of the same order, that the method of replication employed in the experiment (see note at foot of Table X) was reasonably successful in eliminating differences between the treatments due to natural variations of this factor within the experimental area.

Figures in ordinary type are the actual data obtained. Figures in *italics* show the same data adjusted to a common level of initial infestation (based on the figures in column (7)), and scaled down to bring the number of new cases under the Cymag-sodium-silicofluoride treatment to 100. It is a matter of opinion which series of figures should be used in making a comparison between the treatments. Both series, however, lead broadly to the same conclusions.

The first inferences to be drawn from the data are that all four methods gave adequate control (the numbers of losses being small in all cases), but that the trail-injection methods as a group were definitely superior to the crater method as represented in the experiment by the standard Cymag-sodium-silicofluoride treatment. The latter fact is well brought out in columns (5) and (6) of the table, which show that, in order to keep the pest in check, it has been necessary to carry out 25-50 per cent more tree-treatments under the crater than under the trail-injection methods of control. Columns (2), (3) and (4) show that this superiority depends on the much greater efficiency of the trail-injection method in curing infested trees, and in keeping them free from reattack. As regards new cases arising in the treated areas (see column (1)) the advantage appears to lie with the crater method, a fact which suggests that trail-injection has a tendency to drive the termites away to neighbouring trees. This disadvantage, however, is more than outweighed by the greater

TABLE X

*Comparative Tests of "Crater" and "Trail-injection" methods of Termite control at the Experiment Station.
Incidence of infestation and numbers of tree-treatments carried out during the period January 1938
to December 1939*

Method	Treatment Material used	New Cases i.e. "First" treatments	"Repeat" treatments			Total Cases	Trees killed by termites	Nos. of points attacked in corresponding areas from time of planting to commencement of experiment
			On trees infested at previous round	On trees marked as "Recoveries"	Totals "Repeats"			
"Crater"		(1)	(2)	(3)	(4)	(5)	(6)	(7)
	Cynag and sodium- silicofluoride -	161 (100)	223 (139)	54 (33)	277 (172)	438 (272)	23 (14)	264
"Trail- injector"	Commercial Preparation "A" -	177 (117)	72 (47)	26 (17)	98 (64)	275 (181)	11 (7)	249
	White arsenic -	212 (163)	71 (54)	37 (29)	108 (83)	320 (246)	14 (11)	213
	Perchloride of mercury -	207 (149)	43 (31)	29 (21)	72 (52)	279 (201)	12 (9)	228

For details of treatments see Annual Reports of R.R.I. for 1937, p.141, and for 1938 p.133.

The tests were carried out in Fields 4, 7, 8, 9, 11, 15, 16, 17, 18, 20, 22, 25 and 26. To obtain adequate replication each field was divided into quarters, a different treatment being allotted to each quarter. Fields in which a fair division could not be made were excluded from the experiment. The total area under experiment was approximately 400 acres i.e. 100 acres under each treatment.

efficiency of trail injection in curing and protecting infested trees, and in reducing the number of tree losses; the net result being more effective control with a smaller number of tree-treatments.

Comparing the different materials used in the trail-injection treatments, plain white arsenic has proved to be the least effective, the results with this material lying about mid-way between the results of the other trail-injection treatments and those obtained by the crater method. Between Commercial Preparation "A" and perchloride of mercury there is little to choose. Perchloride of mercury has given more new cases during the course of the experiment, but has compensated for this by a greater efficiency in curing and protecting infested trees.

Comparative cost figures covering the period of the experiment are given in Table XI. The figures are given separately for the different years to show that the treatments maintained substantially the same relative positions (with regard to cost) from year to year. The figures in the columns headed (1) confirm the superiority of the trail-injection over the crater method as regards efficiency of control. Columns (2) and (3) show, however, that in the case of Commercial Preparation "A", the advantage gained on the score of efficiency has been entirely nullified by the high price of the material.

Combining the data of Tables X and XI, perchloride of mercury, applied by trail-injection, will be seen to have proved the most successful and economic method used in the experiment. This method has a further advantage over the arsenic treatments in that it is not attended by any danger of bark burning (see Annual Report for 1938, p. 133). The difference in cost and efficiency between perchloride of mercury and white arsenic is small, however, and it is thought that the relative positions of these two treatments might have been reversed if improved qualities of white arsenic and specially designed dusting machines had been available. Improved qualities of white arsenic would probably also have eliminated, or greatly reduced, damage from bark burning.

It may be noted here that Commercial Preparation "A" consists principally of white arsenic, and that its slight superiority over commercial white arsenic, as shown in the experiment, almost certainly depends on superior physical and chemical properties imparted by processing. The claim made by the manufacturers, that the efficiency of the preparation depends mainly on the presence of a micro-organism exerting a type of biological control, may be discounted.

TABLE XI

Comparative costs of the different Termite control methods employed at the Experiment Station during the years 1938 and 1939

Treatments		Areas treated in 1938 (acres)	Costs in 1938 (dollars per acre)			Areas treated in 1939 (acres)	Costs in 1939 (dollars per acre)		
Method	Material used		Labour (1)	Materials (2)	Total (3)		Labour (1)	Materials (2)	Total (3)
"Crater"	Cynag and sodium-silicofluoride ...	182	0.86	0.38	1.24	174	1.13	0.27	1.40
	Commercial Preparation "A" ...	132	0.52	0.94	1.46	198	0.83	0.98	1.81
"Trail" injection	White Arsenic ...	207	0.56	0.02	0.58	281	0.82	0.01	0.83
	Perchloride of mercury ...	132	0.52	0.15	0.67	137	0.57	0.12	0.69

These figures refer to the whole area coming within the monthly routine round of termite control, including the fields from which the data of Table X were obtained. Separate costs figures for the latter fields are not available.

Other Insect and Animal Pests (Mr. Beeley)

THRIPS, SPIDERS AND MITES

Probably greatly aggravated by the dry weather, the damage caused by these minor pests of *Hevea* has attracted increasing attention during the past year, and though buddings of some clones appear to be inherently susceptible to these pests, in others the incidence of this form of damage appears to depend on the adverse weather conditions obtaining during the critical period of the growth flush when new foliage is developing.

Sulphur dusting for control of these pests was again carried out more or less generally on the Experiment Station during the refoiliation period of 1939.

CATERPILLARS

Several outbreaks of caterpillar attack on rubber trees and covers, as reported in the Annual Report for 1938 p. 134, have occurred during 1939. In addition reports of similar caterpillars attacking the renewing bark of the tapped panel of mature trees have been confirmed. Such outbreaks are usually very localised and as a rule are easily controlled. Towards the end of the year a rather serious infestation by larvae of a Psychid moth occurred on *Albizia* interplanted with the rubber trees.

The problem of its occurrence and possible methods of control are being investigated by the Entomologist.

SNAILS, SLUGS AND RODENTS

Considerable damage is still being caused by slugs and snails to young rubber trees and cover plants, though the dry weather has been unfavourable for them. Protection of nursery beds and young plants in the field can be accomplished by occasional baiting with "Meta"-bran.

The popularity of opening new clearings from jungle with only a light burn or with no burn has increased the importance of the rat and to a less extent the squirrel menace on rubber estates. The circular dealing with this problem was revised and enlarged for general distribution to estates. Of considerable interest is the booklet issued by the Institute for Medical Research*

*Rat Virus Enquiry Report Including a Note on the Raticidal value of certain Commercial and other chemical poison by J. T. Paranjothy, Bulletin No. 1 of 1939, Institute for Medical Research, F.M.S.

describing the results of researches into the problem of rat control by virus and poison baits. No virus has been found to be effective on rats in Malayan tropics, and control of the pest must be accomplished by chemical poison and trapping. In this booklet experiments are described which show very effectively the difference in efficacy of various baits according to whether alternative unpoisoned food is available or whether the rats are previously starved and have only the poisoned bait upon which to feed. For example by feeding known weights of bait to starved rats in cages, having no alternative food, it was found that barium carbonate and arsenicals were more effective than phosphorus and thallium baits. Similar tests on herds of rats in cages, provided with suitable alternative food as well as the poisoned bait, indicated that the phosphorus and bread baits were superior, followed in descending order of merit by thallous sulphate and bran, red squill and chocolate, arsenicals in bran or bread, while the barium carbonate bait remained practically untouched.

A further test by the same authority to determine the attractiveness of fruit, meat and farinaceous bases for bait showed rice, ripe palm oil fruit, or plain white bread to be most attractive, while rolled oats, bran and flour balls or salt fish were less attractive. Fresh bait is very much more attractive than bait exposed to the atmosphere for a few days.

DISEASES AND PESTS OF COVER PLANTS

Again owing to the long spells of dry weather which have occurred throughout the year the legume aphid *Aphis laburni* has been troublesome on creeping covers especially *Pueraria* sp. and *Calopogonium* sp. The coccinellid *Epilachna indica* in larval and adult form was also reported very frequently during the first half of the year. Fungus parasites were rare except in patches of rubber affected by root diseases.

Further investigations were made into the occurrence of the root-knot eelworm *Heterodera marioni* and a paper was published about the middle of the year (see p. 194). A number of species of legume plants have been established in infested soil at the Experiment Station and will now be tested for tolerance of shade of rubber trees and persistence under such conditions.

The following is a list of insect and other pests of rubber trees or cover plants identified during the year:

NAME	TYPE	PLANT ON WHICH FOUND
<i>Aphis laburni</i>	.. Aphid (Black fly)	Legume covers
<i>Cicada</i>	... Large bug	Covers and <i>Hevea</i>
<i>Clania variegata</i>	... Caterpillar	<i>Hevea</i>
<i>Cyana Ridleyi</i>	.. Caterpillar	<i>Hevea</i>
<i>Epilachna indica</i>	... Coccinellid beetle	Legume covers
<i>Ferrisia virgata</i>	... Mealy bug	<i>Hevea</i>
<i>Glycyphana minima</i>	... Cetoniid beetle	<i>Hevea</i>
<i>Gonocephalum</i> sp.	... Tenebrionid beetle	Legume covers
<i>Heterodera marioni</i>	... Eelworm	Legume covers
<i>Homoeocerus serrifer</i>	... Bug	Legume covers
<i>Hypomeces squamosus</i>	... Weevil	<i>Hevea</i>
<i>Lamprosema diemenalis</i>	... Caterpillar	Legume covers
<i>Lecanium nigrum</i>	... Scale insect	<i>Hevea</i>
<i>Lycinae</i>	... Net-winged beetles	<i>Hevea</i>
<i>Miltochrista</i> sp.	... Caterpillar	<i>Hevea</i>
<i>Miresa bracteata</i>	... Caterpillar	Covers
<i>Nisitra vittata</i>	... Cricket	<i>Hevea</i>
<i>Orygia turbata</i>	... Caterpillar	<i>Hevea</i>
<i>Pagria</i> sp.	... Chrysomelid beetle	Legume covers
<i>Pseudococcus</i> sp.	... Mealy bug	Legume covers
<i>Pulvinaria maxima</i>	... Scale insect	<i>Hevea</i>
<i>Riptortus linearis</i>	... Bug	Covers
<i>Tarsonemus translucens</i>	... Mite	<i>Hevea</i>
<i>Tiracola plagiata</i>	... Caterpillar	Young plants and covers
<i>Valanga nigricornis</i>	... Grasshopper	<i>Hevea</i>

Bacteriology (Mr. Beeley)

SOIL

Again no work dealing directly with soil microbiology has been carried out, owing chiefly to lack of time. Work on legume nodule bacteria was continued throughout the year with the able assistance of Mr. John. This work has consisted chiefly of supplying cultures of various strains of *Rhizobium* to estates for direct use or for multiplication in skim-milk phosphate solution before applying it to the seed of the species to be inoculated. This multiplication process, described in this section of the report for 1938, appears to work quite satisfactorily on estates and effects a considerable saving in costs of culture, so that no charge is made by us for the original test-tube cultures supplied to estates.

During the year some 245 estates have been supplied with cultures to the total of 1,353 tubes comprising the following strains:—

<i>Centrosema</i>			
<i>pubescens</i>	1,005 tubes	<i>Pueraria javanica</i>	288 tubes
<i>Calopogonium</i> sp.	44 „	<i>Tephrosia</i> sp.	7 „
<i>Crotalaria</i> sp.	nil „	<i>Desmodium</i> sp.	5 „
<i>Vigna</i>	1 „	<i>Desmodium</i> T.	3 „

Owing to the dry weather experienced almost throughout the year there was a considerable amount of failure of covers while still in the seedling stage, but on the whole estate managers express satisfaction with the results obtained by inoculation of legume seed before sowing.

The Soils Division of this Institute has also been supplied with a number of tubes of culture for field experiments to which reference is made in the report for that Division.

Further experiments were carried out to determine the nitrogen-fixing properties of the various strains of *Rhizobium* now in commercial use. Various species of plants were grown in sterilised soil/sand mixture in pots and inoculated with their respective strains of nodule organism. Previous work has indicated that soil of this type required for a satisfactory growth of legumes a mineral manure containing potash, phosphoric acid, lime, magnesia and iron at the rate of 8 to 10 cwt. of the mixture per acre applied in small doses throughout the period of the experiments. After a period of four months growth the plants had grown vigorously and on analysis were shown to have taken up considerable quantities of Nitrogen. *Centrosema pubescens* plants contained an average weight of 2.47 gms. of nitrogen per pot, *Pueraria javanica* 1.75 gm., *Tephrosia candida* 1.16 gms. and *Crotalaria anagyroides* 0.77 gms. of nitrogen per pot. Taking one square foot surface area per pot the nitrogen in the *Centrosema* plants was equivalent to an application of 1185 lb. of sulphate of Ammonia per acre. It should be noted that when the plants were taken up for analysis the nodules were still intact though a few yellowing leaves had probably been lost. Under field conditions it has been observed that perennial legumes of this type have seasonal growth periods and wintering periods. During the latter, which usually occur during drought, the nodules and rootlets appear to disintegrate and become absorbed into the soil. When the new growth flush commences new rootlets and nodules are produced and the aerial parts begin to assume a new, vigorous, green colour.

To determine whether much of the nitrogen fixed by the nodule bacteria becomes available to the rubber trees or other plants growing in the soil, a comprehensive pot experiment has been laid down in which rubber plants are being grown in large pots, some with legume covers, others with non-legume covers, and others without covers, with and without nitrogenous manures.

LATEX

Work on the bacteriology of latex has continued throughout the year. Firstly, in co-operation with the Chemical Division, investigations were undertaken into the development of bacteria in latices preserved by Spence's method which involves the use of sodium phosphate buffer solution; it was shown that this method of stabilisation and preservation is not applicable to fresh latex. An investigation was also carried out for the Chemical Division into the bacterial content of fresh latex preserved with "Santobrite" and small quantities of ammonia. It was shown that latex to which is added 0.1 per cent ammonia and 0.3 per cent by weight of Santobrite becomes sterile within a few days and thereafter is adequately preserved for commercial purposes. A more detailed report of the above will be found in the report for the Chemical Division and in separate communications.

During the year attempts have been made to obtain a latex with a comparatively low content of bacteria under ordinary commercial tapping conditions in which the bark, utensils, hands etc. have been thoroughly disinfected and the tapping panel covered with a sterilised rubber sheet immediately after tapping. In spite of these precautions however a latex containing less than 10,000 organisms per cubic centimeter was rarely obtained, while the numbers varied considerably in latex from the same tree from day to day.

It was suspected, and subsequently proved conclusively, that while the inner cortex remote from the tapping cut is bacteriologically sterile, the inner cortex immediately below the tapping cut may contain numerous bacteria which serve to inoculate continuously all latex drawn from that tapping surface. It has also been shown that after the latex has finished flowing on the morning of tapping there still remain in the bark a few hundreds or even thousands of bacteria per one inch section of cut, which multiply rapidly in the latex tubes and thus form an adequate inoculum for the latex passing through that section of the panel at the next tapping. At a distance of just over one inch below the tapping cut the inner cortex may be considered sterile.

It should be mentioned that the bacteria found in the bark are of the facultative aerobe type, growing equally vigorously

in air or in an atmosphere free from oxygen. They form the greater bulk of bacteria normally found in field latex. They produce large, whitish, slimy colonies with much gas, whereas the pigment-producing bacteria found on the surface of latex grow more slowly, do not produce gas and are obligate aerobes, giving no growth in the absence of oxygen; they appear to be derived from air-borne contamination. Thus, as is indicated by our daily count records, latex obtained during a moist season contains less bacteria than latex obtained during a dry season when the atmosphere contains more dust, spores etc. Similarly a cleaner latex is obtained from a dry panel the morning after a shower the previous evening, but night or early morning rains, such that the panel is wet at tapping time, usually cause a heavy contamination of the latex by both bacteria and fungi.

In co-operation with the Chemical Division, investigations into the natural coagulation of latex have been made with a view to determining how far this method of coagulation might be commercially adopted in view of the temporary shortage of acid coagulants. The inoculation of latex with suspensions of the facultative-aerobic bacteria cultures mentioned above did not noticeably improve the rate of natural coagulation of field latex nor the texture of the resulting coagulum. The addition to the latex of 20, 50 and 100 per cent on volume of an activated yeast extract did not materially affect the rate of coagulation, but the texture of the resulting coagulum was more even and softer the greater the volume of fluid added. Similar results were obtained by addition of rennet extract and of rice cake (*Mucor ferment*) extract. Dilution of latex with water tends to delay natural coagulation and to produce a less satisfactory gritty coagulum with a very milky serum.

All the above tests were in duplicate and repeated over several day's latices. A similar series was set up in test-tubes contained in Buchner tubes containing alkaline pyrogalllic acid. It was shown that such anaerobic conditions have little if any effect on rate of natural coagulation, but that the resulting coagulum is more even throughout in texture, in size of bubbles and in clearness of serum, while the top surface is free of alkaline decomposition products. The texture of coagulum produced under anaerobic conditions was softer than that produced under aerobic conditions, but this advantage is short lived as the coagulum appeared to harden rapidly on exposure to air during the rolling process.

Experiments with colour pH indicators demonstrated the production of alkaline products on the surface of latex exposed to air, and that the surface latex does not form a coagulum like that lower down the container but becomes an alkaline paste which may later dry to form a skin of dry rubber. Though vivid colour

changes were registered by the surface medium, the lower serum and coagulum showed no noticeable change in colour after 24 hours, thus confirming previous findings that there is very little change in pH of latex during the earlier period after tapping up to and including the point of spontaneous coagulation. Storage of fresh latex in a cold incubator at 22°C, while greatly reducing the number of bacteria per cc. just before flocculation, does not materially delay such flocculation and coagulation.

Advisory Work

VISITS AND INTERVIEWS

Visits to Estates other than Experiment Station ...	80
Visits to Experiment Station and Small-holdings ...	24
Interviews at the Institute	85

SPECIMENS EXAMINED

Leaves	107
Roots	61
Bark	13
Stumps	4
Branches	23
Seedlings	31
Fructifications, Fungus etc.	10
Cover plants	69
Insects	79
Fungicides and Insecticides	2
Total ...	399

LECTURES

1 and 2 "Inoculation of Leguminous Cover Plants" by F. Beeley: District Planters' Association, Kuala Langat, on 10.5.39; and by K. P. John: Nilai District Estate Asiatic Staff Association at Seremban on 16.4.39.

3 and 4 "Diseases and Pests of Young Rubber and Covers" by F. Beeley: Pahang and Taiping Branches of Incorporated Society of Planters, at Raub and Taiping, on 4.6.39 and 28.3.39 respectively.

PUBLICATIONS

1. Palm Oil Diluent for Tar Oil Fungicides, and its effects on Bark Renewal in Hevea by F. Beeley and E. D. C. Baptist
Journal of R.R.I.M. Vol. 9, No. 1
2. A Nematode Pest of Roots of Cover Plants by F. Beeley
Journal of R.R.I.M. Vol. 9, No. 1
3. *Oidium Heveae* in 1939 by F. Beeley
Journal of R.R.I.M. Vol. 9, No. 1

CIRCULARS

The following circulars were prepared by F. Beeley for general distribution during the year.

- No. 2 Brown Bast of Rubber Trees
- No. 3 Insect Pests of Rubber Trees and Cover Plants
- No. 7 Rat Control
- No. 10 Suggestions for the Establishment of Leguminous creepers under mature Rubber Trees (jointly with Botanical and Soils Divisions)
- No. 11 Drought and Fire Damage (Published January 1940)

Advisory Leaflets for limited distribution to assist in the advisory work were also prepared as occasion demanded.

TOURS

(a) F. Beeley

1. Teluk Anson District, Sitiawan District, North Perak and Kedah, Selangor, Negri Sembilan, Malacca and Johore
Oidium Heveae
2. Perak and Kedah
Cockchafer Grubs and other pests
3. Negri Sembilan and Johore
Cockchafer Grubs

(b) R. P. N. Napper

- | | |
|--------------------|---|
| 1. Johore | Root Disease Control |
| 2. Perak and Kedah | Root Disease eradication and cockchafer experiments |

F. BEELEY

Head of Pathological Division

Kuala Lumpur,

20th February, 1940

**Key to locality of experimental centres referred to
by index letters in the text.**

B.K. = Batang Kali Estate, Ulu Yam, Selangor

(Anglo Malay Rubber Co., Ltd.)

H. = Highlands Estate, Klang, Selangor

(Highlands & Lowlands Para Rubber Co., Ltd.)

L.P. = Lower Perak Estate, Teluk Anson, Perak

(Lower Perak Rubber Estates Ltd.)

ANNUAL REPORT
PATHOLOGICAL DIVISION

INDEX

	Page
Advisory work, summary	193
Bavendamm's test for wood-rotting fungi	171
Black stripe	172
Brown Bast	173
Buddings, diseases of	173
Bark-bursts	173
Bacteriology of latex	191
Cockchafer	177
Caterpillars	187
Cover plants, diseases and pests of	188
Cultures of various strains of nodule bacteria	190
Coagulation (natural) of latex	192
Circulars	194
Fungicides for diseases of the tapping panel	172
Identification of wood-rotting fungi	171
Insect pests of rubber trees and cover plants	189
Inoculation of legume seed	190
Interviews	193
Latex, bacteriology	191
Latex, natural coagulation	192
Lectures	193
Root-disease:	
control in young replanted areas	157
bush-covers susceptible to infection	158, 160
standard recommendation for treatment	158
experiment B.K.1—results of inspection and treatments	160
incidence of infection in bush-cover and in creeping-cover areas	163
costs of control	164
control in new clearings	170
incidence in areas cleared without burning	170
infection may be encouraged by burning	171
Rodents	187
Mouldy Rot, incidence	172
Mites	187
Nitrogen-fixing properties of nodule bacteria	190
<i>Oidium</i>	174
Oxidase test for wood-rotting fungi	171
<i>Phytophthora</i> diseases	172
Patch canker	172

							Page
Pink disease	...	...	...	...	...	...	173
Publications	...	...	...	...	...	...	194
Sunscorch of the tapping panel	...		...	...	...	...	172
Spray fluids, effect on plants	...		...	...	...	...	175
Spiders	...	...	...	...	...	...	187
Snails and slugs	...	...	...	...	...	...	187
Squirrels	...	...	...	...	...	...	187
Specimens examined	...	...	...	...	...	...	193
Termites, comparative tests of "crater" and "train-injection"							
methods of control	...	...	...	...	...	...	183
Thrips	...	...	...	...	...	...	187
Visits to estates	...	...	...	...	...	...	193/4
Wood-rotting fungi, identification			...	...	...	...	171
"White List" of fungicides	...	...	...	...	...	...	172

ANNUAL REPORT OF
CHEMICAL DIVISION

ANNUAL REPORT *

CHEMICAL DIVISION

During the year the complement of research officers has been below establishment strength. Dr. K. C. Roberts left at the end of 1938 to take up an appointment with the British Rubber Producers' Research Association and although attempts have been made to secure a successor up to the present none has been appointed. The writer took over the duties of Head of the Division in May from Mr. Hastings who had acted in the interim period subsequent to the departure of Dr. Roberts. Mr. Piddlesden proceeded on leave in July. Messrs. Wentworth and Hastings have been on duty throughout the year; three officers therefore were available for the greater part of the year with a fourth for about two months. Mr. Piddlesden continued his duties as advisory officer prior to his departure on leave, after which the advisory work of the Division was dealt with chiefly by Mr. Wentworth.

It was anticipated at the outbreak of the war that the normal work of the Division might have to be adjusted to meet special problems as they arose and in September a situation developed with regard to the supplies of chemicals, and of coagulants in particular, which threatened to create a difficult situation for the industry. The work on this problem was therefore given priority over other work but it has been possible to continue long-term research and other investigations in progress.

Latex

GENERAL

An increasing interest in latex occurred during the year owing to developments in its utilisation in the manufacture of special types of goods, particularly by the larger manufacturing companies in the States. The writer observed during his visit to America in the Spring that increased manufacturing facilities were being installed by these companies to meet the growing demand which then existed and which it is understood still persists. This has been reflected in an increase of activity and interest in latex in this country.

Relatively small estates which are able to dispose of their latex by direct contacts with dealers or users continue to do so but there has been a noticeable trend for latex to be handled by organisations with large bulking facilities and it is anticipated that the shipment of latex in tankers will increase. These organisations purchase their latex direct from the estates, including

* An index follows p. 217.

small-holdings, supply the ammonia for preservation and the drums for the conveyance of the latex to the bulking and concentration stations and also offer a price which appears attractive to the producer.

With the expiration of the Utermark patent, the field of operations for latex concentration has been widened and demonstrations showing the process of centrifuging have been staged in the laboratories. These were attended by appreciable numbers of estate officials.

TESTING

The Crude Rubber Committee of the American Chemical Society published during the year its proposed methods of testing latex. These have formed a subject of discussion for some time upon which this Institute has been consulted. The methods of determining dry rubber content and ammonia are of particular interest especially from a trade point of view. The British Standards Institution has also evolved a specification for testing latex, upon which the views of the officers of this Division have been given. The method proposed by the latter Institution was suggested for preserved latex only but it is being used in these laboratories for the examination of both preserved and concentrated latex. In the case of the Crude Rubber Committee's method no distinction is drawn as to its use for any particular type of latex. The two methods differ in details of technique and these are being investigated to ascertain if they affect the results materially.

QUALITY

(a) *Sludge in Latex*

The removal of sludge from latex is of importance in connection with its subsequent conversion into sheet as well as when it is to be shipped as latex. The general practice on estates is to allow the sludge to settle out of the latex in large tanks but interest is now being shown in clarifying machines. A machine marketed by the Titan Company of Copenhagen under the name of a "Rotojector" has been available for making tests on the cleaning of latex. The machine works on the principle of a centrifuge at a speed of 6,000 R.P.M. and needs to be washed out with water periodically in order to eject the dirt. It has a throughput of approximately 180 gallons per hour.

Some experimental data, obtained with this machine, showed that a latex having an original sludge content of 0.088% (containing 42.68% ash) had after cleaning a sludge content of 0.02% (containing 11.06% ash). It was observed that most of the sludge

remaining after the cleaning of the latex consisted of organic matter which increased after standing for some weeks. A small commercial sample of the cleaned latex was sent to London for examination.

Data have been collected on the effect of the degree of ammoniation of the latex on sludge formation. Latex ammoniated with amounts of ammonia varying from 0.21% to 1.02% showed on standing for 21 days a gradual diminution in sludge formation (as determined by repeated washing and centrifuging) ranging respectively from 0.137% to .064%. The latter contained a much higher proportion of mineral matter and the results are probably explained by the carrying down of a larger amount of rubbery material in the case of the less ammoniated latex.

Small-scale investigations on the amount of sludge which settles from latex on standing indicate that the bulk is removed by running off the lower layer comprising about 5 per cent of the total volume of latex and that the major portion forms in the first few days. It is appreciated that these observations may not hold in the case of large-scale settling tanks and it is hoped to measure the rate of settling of the sludge in a larger scale apparatus.

(b) *Latex Discoloration*

Our colleagues in London drew our attention to the possibility of flavines preventing the discoloration of latex. These substances act generally as inhibitors of bacterial growth and it was anticipated, on the assumption that the discoloration of latex is caused by the action of bacterial products on iron, that they would lessen the risk of discoloration. They were found however to be ineffective in preventing the discoloration of latex in contact with iron if ammoniation was delayed but were shown to have some effect with freshly ammoniated latex. Their sphere of usefulness is limited however on account of their colour which restricts the quantities that can be used. Flavines are also expensive but subsequently a cheaper material, Dyestuff No. 37914, became available through the courtesy of the British Non-Ferrous Metals Research Association, which gave results similar to those observed with the flavine compounds. This material is open to the same objection of being dark coloured and the quantity which can be utilised is limited as a consequence.

In the Annual Report (1938) it was stated that work was in progress with a view to finding an alternative material to latex-zinc oxide for filming drums. It has been shown previously that the filming of drums with this material is sufficient to protect latex from discoloration but it has the effect of reducing the stability of the latex. This is not necessarily a disadvantage with modern

latex compounding and the lining of drums with zinc oxide-latex mixtures is practised commercially, more particularly when second-hand drums are utilised. On the other hand the knowledge that zinc oxide, which reacts with ammonia forming zinc-ammonium compounds, has an adverse influence on stability has doubtless prevented its more general adoption. The need of a filming material other than zinc oxide-latex compounds may assume greater importance under the present world conditions, when it may not be possible to obtain a constant supply of new drums at reasonable prices.

Experiments have been in progress in which titanium oxide has replaced zinc oxide in the formula recommended (*J.R.R.I.M.* **6** 86) and in which comparative tests have been made with latex stored in drums treated with (a) titanium oxide-latex mixture and a zinc oxide-latex mixture together with latex kept in an unfilmed drum as a control. After 50 days it was observed that the colour of the latex from the zinc oxide-latex-treated drum was good, whilst the latex from the titanium oxide-latex-filmed drum was slightly better. The latex in the control drum was off colour. These differences were emphasised still more after three months' storage.

A number of observations have been made on the effects of the two types of film on stability, periodical tests being carried out with both the Hamilton Beach high-speed stirring test and the L.A.C. zinc oxide-stirring test (2,000 revs.). Whilst some inconsistencies have appeared in the individual tests they show generally that the stability of the latex from the unfilmed drums may be as good as the stability of the latex from the drums filmed with titanium oxide latex, but in each case the stability of the latex from zinc oxide-latex-filmed drums is very much reduced. The results are very favourable to titanium oxide. The titanium oxide-latex mixture is easier to prepare and it is also easier to apply than the corresponding zinc oxide-latex mixture. Further it gives a film on the drums which appears to be more uniform. On the other hand titanium oxide costs approximately twice as much as zinc oxide, but this is relatively unimportant as compared with the cost of purchasing and cleaning second-hand drums.

PRESERVATION

(a) *Spence's Method*

A novel method for the preservation of latex has been suggested recently by Spence whereby the use of alkalis or bactericides is eliminated, and considerable interest has been shown in his process. It consists essentially in the addition of a buffer solution of pH 7 to latex at or around a pH of 7 followed by

sterilisation by autoclaving. The buffer solution suggested consists of sodium dihydrogen phosphate and sodium hydroxide in such proportions as to give a solution of the required pH. Preliminary experiments on latex containing a buffer with or without subsequent autoclaving gave negative results. It has been observed that the pH of several samples of field latex examined in the laboratories was approximately 6.5 but when the pH was raised by the addition of small quantities of ammonia to nearly 7 preservation was still unsatisfactory from a practical point of view.

The original investigations of Spence were made probably with de-ammoniated latex and it was observed with this type of latex that on the addition of various quantities of buffer solutions followed by autoclaving the preservation was more effective.

As a result of the investigations the opinion was formed that the method was of no value as a potential commercial process of preserving fresh field latex. The work was carried out in conjunction with the Pathological Division and a short note has been prepared for publication in the Journal.

Reference was made in previous reports to the preservative action of sodium pentachlorophenate. This is marketed under different trade names viz. Santobrite, Dowicide G and Uniexol G although analyses have shown that some variation exists in their composition. It has been observed that the preservation of latex can be achieved for periods of one year using 1% of sodium pentachlorophenate in the absence of ammonia, sterility being attained after 10 days. Other chlorphenates such as sodium trichlorophenate also preserve latex effectively for long periods if 1% is used. On the other hand if 0.1% of ammonia is used the amount of sodium pentachlorophenate may be reduced to 0.3% and with 0.2% of ammonia only approximately 0.15% of sodium pentachlorophenate is necessary. By this means the total quantity of added preservative may be substantially reduced as compared with the weight of ammonia usually added.

A number of other preservatives have been tested some of which are effective particularly in the presence of quantities of ammonia of the order of 0.2%. Some of these have the advantage of being non-toxic. On the other hand other materials such as phenyl boric acid have been found to be of no value as preservatives.

CONCENTRATION

(1) *Creaming*

(a) *Manucol*

The staff of the London Advisory Committee forwarded three samples of "Manucol" with the request that an investigation

should be made of the relative merits of these materials. These samples were of interest in so far as they are essentially of the same chemical composition but by a variation in their method of manufacture it is possible to prepare materials which give aqueous solutions of different viscosities. Thus the viscosities of one per cent solutions varied from approximately 12 to 150 centipoises and the optimum amount (for creaming) of the material having the highest viscosity was approximately half that of the material having the lowest viscosity. It could not be confirmed, however, that the optimum amounts of the three materials gave aqueous solutions of roughly the same viscosity, the viscosities ranging from 4.24 (in the case of the most viscous material) to 2.21 centipoises (in the case of the least viscous material). As a corollary it was observed also that solutions adjusted to give the same viscosity by varying the quantities of creaming agent did not have the same creaming power. Nevertheless efficient creaming is produced by using a smaller quantity of Manucol than Tragon A and although the price of the material is higher this makes it competitive. Manucol solutions moreover are more stable and contain less insoluble material and consequently the resultant cream is cleaner.

(b) *Schisa Gum*

Other materials which have been tested as creaming agents include "Schisa Gum." Schisa gum is a hemicellulose which is extracted by means of a special refining and crushing process from the cotyledon of vegetable seeds, particularly locust bean, and is therefore similar to Tragon seed gum. It is marketed in several grades and successive consignments have been examined with a view to testing their uniformity. As in the case of Tragon seed gum it is possible to prepare a solution of much higher viscosity by boiling and consequently to reduce the optimum amount of creaming agent required. The results obtained with the better quality Schisa gum were at least equal in efficiency to those obtained with Tragon seed gum.

(c) *Preparation of Creaming Agent Solutions*

Reference has been made already to the influence of viscosity on the creaming power of a gum and in view of the effect which the method of preparation and period of storage have on the viscosity of certain gums data have been collected which will be of value in the practical process of creaming latex.

Solutions of Tragon seed gum may be prepared in the cold or alternatively they may be prepared by boiling. On standing for any appreciable length of time they lose their viscosity and

develop acidity owing to fermentation, with a resultant offensive odour.

Considerable differences in the viscosity of Tragon seed gum solutions have been observed if these are prepared in the cold and by boiling. Solutions prepared by boiling have a viscosity of about 10 times that of solutions prepared in the cold and the optimum amount required for creaming may be reduced by approximately 25 per cent. After about three days the solutions in both cases decompose and lose their ability to cream latex.

The inability of a solution of Tragon seed gum to retain its viscosity over any considerable period is a disadvantage which may be overcome by treating the solution with a small quantity of ammonia. This reduces the initial viscosity but although a gradual decrease in viscosity occurs on storage, the creaming power even in the presence of 0.1% of ammonia is preserved for some weeks and the solutions cream satisfactorily. Tamarind seed solutions can also be preserved satisfactorily with ammonia and the solutions retain their creaming power on ageing. Further studies on the effects of other disinfectants on the preservation and creaming efficiency of gums are being continued.

(d) *Practical Trials*

The usual procedure in creaming with Tragon seed gum is to add a 3% solution at the rate of 0.2% of the creaming agent on the volume of the latex, and allow the mixture to stand for 48 hours or a longer period as desired and then to run off the serum. It is known that ammoniated latex which has aged creams more satisfactorily than when it is freshly prepared. Obviously this factor is utilised if the latex is allowed to remain for a long period during creaming. This is preferable from a practical point of view to keeping the latex for a period before adding the creaming agent.

One method is to fill the tank with the latex-creaming agent mixture over a period of seven days, allow the mixture to stand for say two weeks and then to run off the serum. An alternative method is to run off the serum each day before the addition of that day's latex-creaming agent mixture. When the tank is full the mixture is allowed to stand for say a further two weeks, when any remaining serum is run out. This method saves storage space. The two methods have been tried on a semi-practical scale and it has been found that the latter method gives slightly better results.

(2) *Centrifuging*

Attention has been directed to the commercial aspects of centrifugal machines and during the year the Staff has had an

opportunity of examining critically the performance of the best known machines on the market, including the Sharples, de Laval, Westfalia and Titan. In the early part of the year the Chemical Engineer visited Sumatra and through the courtesy of the Good-year Plantations Company was able to observe the Sharples machine in operation.

A de Laval machine was installed in the laboratories of the Institute for a few weeks and tests and demonstration runs were carried out in co-operation with a research engineer of the company. This was followed by a Titan machine which was under test for about a month in charge of an engineer of the company. A Westfalia machine arrived during the year and is available for experimental and research work on centrifuging.

Our experience with the different machines showed that whilst any one may have advantages in certain directions it has disadvantages in others; each machine is capable of improvement in one way or another. In stating briefly our opinion as to the relative merits of the different machines it must be borne in mind that this is based on the results of tests with machines of the designs available at the time the tests were made. As the market expands the demand for centrifugal machines will cause the manufacturers to make improvements in the design of their machines, and this will react in favour of the latex producer. A number of improvements will be made in several of the machines as a result of the tests made in the Institute's laboratories.

The Sharples machine has a low power-consumption and is extremely well constructed. The bowl and plates are made of stainless steel. It has an average efficiency but the running time, before cleaning becomes necessary, is short. Starting, stopping and bowl changing are rapidly and easily carried out. The cost of the machine is relatively high as compared with those of other machines.

Two de Laval machines are produced having throughputs of approximately 45 and 90 gallons per hour. The machines are well constructed and include stainless steel plates. Both machines have an average efficiency and the bowls do not choke easily. The operations of starting, stopping and cleaning can be carried out in a reasonable time. The cost is about half that of the Sharples machine with a similar output.

The throughput of the Westfalia machine is the same as that of the Sharples and the smaller de Laval. The efficiency is higher than those of other machines. Running time is satisfactory but cleaning is laborious. On the whole the advantages of this machine appear to outweigh the disadvantages.

The Titan machine, when tested, was considered to be still in the experimental stage and it is anticipated that improvements in

design will be effected as a result of the experience gained in Malaya and Sumatra. The machine is of the orthodox type but has several novel features. The essential parts are of stainless steel. The throughput is similar to that of the smaller de Laval and the Westfalia and the efficiency lies about midway between those of these two machines.

The choice of machines is at present rather limited. The Sharples is expensive, the Westfalia is of enemy manufacture and consequently not available and the Titan machine is not yet on the market, but it is anticipated that this position will change in the near future. It is unfortunate that British manufacturers of centrifuges have not given more attention to the latex market.*

Modified Rubber

(1) PREPARATION OF SOFTENED RUBBER

Considerable interest has been taken in the preparation of softened rubber by means of the addition of peptisers to latex before coagulation. The methods evolved in the laboratory have been translated into large-scale production in the estate factory without any appreciable difficulties being encountered. Progress has been made in the process of preparing softened rubber on the plantation by means of the incorporation in the latex of the peptising agents R.P.A. No. 2 and R.P.A. No. 3.

Data have been obtained regarding the influence on softening of the drying temperature of the wet coagulum obtained from latex to which peptisers have been added and it has been found that the initial temperature of drying has the greatest influence on the degree of softening produced. High temperatures in the early stages of drying appear markedly to assist softening; high temperatures in the later stages of drying after an initial period of drying at low temperatures do not have the same result as that produced by a short period at a high temperature followed by completion at a low temperature. In large-scale production careful and accurate control of the drying temperature of the wet sheet would be necessary and this has been found to be practicable. The possibility of using the ordinary smokehouse for the drying of the wet sheet has been investigated and it has been found that the smoke has a slight inhibiting effect on the softening of rubber containing peptising agents. A high initial temperature in the presence of smoke was not so effective as the same temperature

* Since this was written Denmark, where the Titan machine is manufactured, has come under German control. There are also difficulties in obtaining exports from Sweden, from which country the de Laval machine was obtained.

in the absence of smoke. The effect of the smoke depended upon the nature of the peptiser, suggesting that reducing agents in the smoke react with it.

A paper describing the investigations on the preparation of soft rubber by the pre-coagulation treatment of latex with proprietary peptising agents, including the results of vulcanisation and ageing tests, was published in the *Journal* as Communication No. 237.

In addition to proprietary peptising agents which are marketed for the purpose of accelerating softening during the milling of the rubber in the factory, a number of other materials which are known to influence the softening of rubber under similar circumstances have been examined to ascertain what effect they have when added to latex before coagulation. Successful results were obtained with compounds having the peroxide and thiazol groupings and provisional application has been made for the protection of processes of softening rubber involving the use of such materials. Vulcanisation tests on the rubber prepared from both types of materials gave no indications that the physical properties were adversely affected.

A survey has also been made of the softening effect produced by the pre-coagulation treatment of latex with conventional softeners some of which are used in rubber manufacture, including stearate, oleate, palmitate and linoleate soaps. It was observed that copper soaps had drastic effects, zinc soaps were superior as softeners but otherwise the softening effects were small. Generally materials which are used in the rubber factory apart from proprietary peptising agents act as diluents and lubricants rather than as chemicals which induce disaggregation of the rubber. The results of this investigation were published in Communication No. 236 of the *Journal*.

The softened rubber produced on a commercial scale by the addition of R.P.A. No. 3 to the latex has been tested by the Staff in a rubber factory and has been submitted also to a number of manufacturers to enable them to make large-scale trials. The results on a factory scale confirmed those observed in the laboratory. On large mixing rolls the rubber softens almost immediately and is sufficiently plastic for the compounding ingredients to be added almost at once.

Samples of softened rubber were submitted to the Director of the British Rubber Producers' Research Association to enable him to make trials with the material in the manufacture of Rubbone, but the rubber proved to be unsatisfactory for the purpose. This may be because the peptising agents retarded oxidation during the Rubbone process, which would support the

view that the softening action induced by peptising agents differs from that usually associated with the softening of rubber by oxidation as for example by mastication (Blake & Bruce, *Proceedings Rubber Technology Conference* 1938).

(2) PREPARATION OF RUBBER OF LOW WATER-ABSORPTIVE CAPACITY

During the course of the work on the preparation of rubber of low water-absorptive capacity both of the tests commonly used, viz. the hot-water-immersion test which is popular in America and the vapour-immersion test which is favoured in England, have been utilised. The hot-water-immersion test has the advantage of giving quick results but it is open to criticism on the grounds that it does not simulate the ordinary conditions of service, that the absorption of water does not attain equilibrium and moreover, that the practical details of carrying out the test have not hitherto been well defined. On the other hand the vapour-immersion test requires an appreciable period of time before equilibrium is reached. It is not surprising in view of the different techniques involved in the two tests that an exact correlation between the results is not always obtained. Nevertheless the influence on the results of the conditions of carrying out the two tests have been examined critically with beneficial results and a paper is in course of preparation for the *Journal*.

Water absorption has been variously ascribed to the presence of water-soluble materials in the rubber, to the influence of the proteins or to a combination of the effects of both types of material. In a number of samples of smoked sheet taken at random, upon which water absorption by three different methods was determined together with non-rubber and nitrogen contents, it was observed that neither of the latter values gave any indication of the water-absorptive capacity though this varied by as much as one hundred per cent.

A survey of the water-absorption properties of estate smoked sheets and crepes has been made and it was found that a few samples of crepe had relatively low water-absorption capacities. Successive samples from a certain estate gave good results and attempts have been made to find out whether this is an inherent property of the rubber or whether it is a result of the method of manufacture. Whilst this rubber shows relatively good results the water-absorptive capacity is not sufficiently low to enable it to be classified as suitable for insulation work (Noble—*Latex in Industry*).

Various aspects of deproteinisation by enzyme action have been investigated and data have been accumulated on the effects of varying periods of contact, the effects of different preservatives

and the concentrations of the preservative and activator. The effect of each of these has been examined at atmospheric and other temperatures in order to find the optimum conditions of the reaction. Combinations of enzyme action with other methods of reducing the nitrogen content have been explored and as a result, a small commercial consignment has been produced in co-operation with an estate. This has been sent to London in response to a request for large scale samples of low-water-absorption rubber.

Technological Studies on Rubber

1. VULCANISATION

(a) General and Testing

The vulcanising and testing equipment has continued to give satisfactory service during the year and the autoclave press to which reference was made in the Annual Report for 1938 has been brought into successful use and is now functioning well. Data have been obtained on the effects on the vulcanisation results of a variation in the mixing technique such as varying the size of the mix, the width of the nip and the time spent in mixing. It has been observed previously that variation in tensile strength can be caused by varying degrees of sharpness of the Schopper knives when cutting the test rings. The policy of using only knives which have been sharpened monthly by the maker is particularly desirable when mixes of the "Captax" type are used. Since the outbreak of the war it has not been possible to send the knives away to be sharpened and rotating blades have been brought into use for cutting the test rings.

Comparative vulcanisation tests have been carried out in collaboration with our colleagues of the London Advisory Committee and also in conjunction with a number of organisations in the East in order to ascertain what measure of uniformity in the results of testing can be attained in different laboratories. All the laboratories which have co-operated are equipped with Schopper testing machines. The information obtained will be of value in connection with the suggested procedure of evaluating rubber on the basis of its vulcanising properties through the medium of definite standards. It is obvious that uniform and reproducible results in different testing laboratories are a necessary attribute of any scheme of such a nature.

(b) Variability of Sheet Rubber

The survey of the vulcanisation properties of a number of samples of smoked sheet drawn from Malayan estates which were

representative of 22% of the planted area of the country was concluded and the results were given in a paper presented to the American Chemical Society at the Goodyear Centenary meeting and subsequently published as Communication No. 243 of the *Journal*. Further samples were obtained from those estates which had been found to give exceptionally slow- or fast-curing rubber in order to ascertain if the original results were abnormal. In most instances the second samples gave results similar to those obtained previously. As far as possible personal investigations are being made on these estates to seek a reason for the abnormality of the rubber. It has been observed as a general rule that the fast-vulcanising rubber is from young estates of which the majority of trees are about 10—15 years old. In no instance has any deviation from standard methods of preparation yet been noted which could be considered responsible for the variation shown. Trial coagulations under different conditions are being made on a number of these estates and the rubber is being tested in comparison with that drawn from the normal estate output.

The reasons why variability is a problem which does not appear to have an immediate solution have been stated so many times that repetition is unnecessary. Whilst they preclude the practicability of the production of uniform rubber over the country as a whole it is considered possible that individual estates can produce uniform rubber over a period. In order to ascertain what degree of uniformity exists in commercial practice arrangements have been made to obtain samples of standard sheet at regular intervals from a number of estates which are known to prepare their rubber in modern factories and to control effectively their methods of preparation. The examination is proceeding and whilst it is yet early to draw definite conclusions the indications are that uniform rubber is produced by certain estates. Included in this series of tests are samples of rubber from the bulked crop at the Experiment Station and also rubber prepared by known variations in the standard procedure. This survey is to be extended to those estates whose rubber is abnormal.

(c) *Influence of Tapping Systems on Vulcanisation Properties*

The effects on the vulcanising properties of three different tapping systems which have been in operation in Field 23 at the Experiment Station since the trees came into tapping three years ago were described in the paper referred to above. It was shown that one of these tapping systems was definitely unsuitable if judged from the point of view of the variability of the rubber produced. These observations were based on bulked monthly samples and the investigation is being extended to a determination

of the day-to-day variation. Arrangements are being made to investigate the variation in vulcanisation properties of both seedling and clonal rubber from a number of other tapping systems.

(d) *Influence of Preparation Treatment on Vulcanisation Properties*

Work has been continued on the effects on the vulcanisation properties of the addition of anti-coagulants to latex and it has been confirmed that a variation within practical limits of the quantities added has relatively unimportant effects.

2. PLASTICITY

(a) *Plasticity of Clonal Rubber*

In the Annual Report for 1938 it was stated that the variation in the plasticity of clonal rubber is caused by inherent differences in the latex rather than by variations in the methods of preparation. Some clones are inherently soft e.g. P.B. 186 and some are inherently hard e.g. Tj. 1. Opportunity has been afforded to obtain rubber prepared under standard conditions from several monoclonal areas of P.B. 186, grown on widely divergent Malayan soils. In all cases the rubber was found to be outstandingly soft. These observations, hitherto made by plasticity measurements, have been confirmed by the measurement of the power consumed during mastication.

On the other hand information was received from a large consumer's research laboratory that the results which have been repeatedly confirmed here could not be obtained in its laboratory and samples were therefore prepared from monoclonal blocks of the clones P.B. 186 and Tj. 1 and despatched for tests. It has been observed that rubber tends to harden on storage which may account for some of the discrepancy, but the relative hardness still remains substantially the same after a long period of storage.

A logical and interesting development in this field is the propagation of clones with the object of producing soft rubber. A survey of the rubber from trees in Field 14F indicated several trees which gave a soft rubber and in collaboration with the Botanical Division these have been utilised to supply budwood for grafting on seedlings in Field 35. Clone P.B. 186 was used as a control.

The determinations of plasticity of the rubber being prepared daily in a tank experiment at the Experiment Station so far confirm the opinion that preparational factors have only a relatively small influence on plasticity.

(b) *Relationship between Plasticity and Latex Constituents*

Investigations have been in progress to ascertain if any relationship exists between plasticity and certain latex constituents. They have had to be suspended temporarily owing to delay in obtaining the necessary solvents but it is anticipated that the materials will become available again in the near future when the work will be resumed.

Coagulants

On the outbreak of the war large stocks of formic acid were not available in the country apart from those held by one or two large estates which had anticipated events and acted accordingly. With supplies from the principal exporting countries interfered with and even cut off altogether, coupled with the dislocation of transport from England during the early transition period it was evident that the energies of the Staff would have to be directed towards finding substitutes to make up the deficiency during the interim period of the exploration of alternative sources of supply to supplement that from England, which prior to the war provided only 30 per cent of the acid consumed. The position as regards coagulants was reviewed in articles published in the *R.R.I. Planters' Bulletin* in October and December.

Investigations were made (a) to determine whether a more conservative use of the formic acid available in the country was possible; (b) to ascertain the possibility of utilising native materials, particularly by the fermentation of aqueous extracts of natural vegetable products; (c) on the possibility of using other chemicals available in the country. These investigations were confined to ascertaining the suitability of the materials for use in the manufacture of sheet, with which the country is primarily concerned.

Anaerobic coagulation was investigated in collaboration with the Pathological Division and the opportunity was taken of comparing the rate of coagulation under anaerobic conditions with that under aerobic conditions and of observing the effects on coagulation of the addition to the latex of yeast and other extracts. Such methods are suitable only for the manufacture of crepe and they have in addition other disadvantages.

Under (a) a method evolved for the utilisation of serum was published as an advisory Circular (No. 8), whereby the possibility of a saving of 50 per cent of formic acid was indicated. Numerous estates experimented with the method and from advices received it was apparent that varied experiences were obtained. Some estates reported very satisfactory results whilst others, even in the same group, produced sheet containing bubbles. It was

evident that a greater risk of bubbly sheet was entailed by using serum-acid mixtures, especially if the latex was prone to pre-coagulation. It was observed that the possible saving by using serum in conjunction with acids other than formic acid was below 50 per cent.

Work under (b) was directed towards the use of materials which can be obtained locally and investigations with pyroligneous acid, fermented coconut water, toddy, Chinese vinegar and aqueous pineapple and tamarind fruit extracts were carried out. The results indicated that some of these materials could be used by small-holders without much difficulty but it was obvious that their use where outputs were large would present difficulties and be tedious owing to the need for special attention in the preparation of the coagulant. Moreover it was found that under the best conditions the acidity of some of these extracts could not be controlled with any degree of accuracy.

Nevertheless information concerning the use of some of these emergency alternative coagulants was disseminated widely through the medium of the Asiatic Rubber Instructors who arranged numerous local demonstrations based on instruction they received at the Institute. The method of using coconut water as a coagulant was published as an advisory Circular (No. 9). Details also were made available concerning the use of other materials if required.

With regard to (c) it was found that an aqueous extract of either ordinary superphosphate or concentrated superphosphate provided a coagulant which was particularly efficient under certain conditions. A satisfactory coagulant was obtained by extracting either of these materials in a 10 per cent dispersion but successive water extracts become weaker and the materials are of no value as sources of coagulants after a second extraction. Although a limited amount of coagulant was extractable the quantity was sufficient to enable it to compete in price with formic acid. Sheet of good appearance can be prepared with superphosphate extract but the properties of the rubber are affected and this militates against its use.

Vulcanisation tests have been made or are in hand on rubber prepared by the use of all the alternative coagulants and apart from the results obtained with superphosphate, which retards the rate of vulcanisation of the rubber probably owing to the presence of sulphates, no obviously harmful effects have been observed. Whereas some of these materials retard others such as serum accelerate the rate of vulcanisation and it is inevitable that if they were used on a large scale they would widen generally the range of variability of Malayan rubber. For this reason and the

fact that experience has shown that no saving in costs is possible, except where certain of the vegetable materials are available locally and small quantities only are required, it has been emphasised that these materials should be regarded as for use only in cases of emergency when normal supplies of acid are not available.

During the last quarter of the year about 40 different samples of materials marketed as coagulants were received in the Division from official and unofficial sources and analysed and tested for their coagulating efficiency. The opportunity has been taken by some individuals to exploit the position and to market coagulants having sulphuric acid as their chief constituent and containing in addition materials such as sodium sulphite, bisulphite or hydrochloric acid to camouflage the material. Even the presence of citronella and camphor oils has been observed in one or two cases. No opportunity has been missed to discourage the use of these miscellaneous mixtures whose composition and often their effects on the rubber are unknown. The controlled price of formic acid has been used as the basis of the market price of these mixtures despite the fact that sulphuric acid is a much cheaper acid and is used in a strength generally of not more than 50 per cent. Certain proposals for regulating the sale of these coagulants have been put forward to the competent authorities.

Estate Technique

(a) DRYING OF SHEET RUBBER

The experimental smoke-house of the Tunnel type which was constructed at the Experiment Station in 1938 has functioned satisfactorily throughout the year and a second smoke-house has been built incorporating a number of improvements which have been indicated as a result of experience gained with the original smoke-house. These improvements have been applied especially to the design of the furnace, involving alterations in structure to counter the effects of the changes in temperature which occur when it is in operation. The principle of the Tunnel furnace has been adapted successfully for use with the Subur smoke-house, giving the required volume of smoke and drying sheet on a more economical basis.

A number of Tunnel smoke-houses have been constructed on estates during the year. These include both the "A" and the "B" types (large and small) which have been built either in wood or brick. It is known that the construction of many more smoke-houses is under consideration, plans and drawings having been supplied to a number of estates. In many cases co-operation

has been sought by the estates and it is hoped to publish a report describing the results obtained with the smoke-houses in operation.

During the course of experimental work on drying it was found that sheet showed an appreciable gain in weight during smoke-drying as compared with air-drying, confirming the work published by Ultee (*Archief v.d. Rubber Cultuur* **7**, 60, 1923) who gave the term "smoke number" to the percentage gain in the weight of the rubber as a result of smoking. He found that the smoke numbers of a series of rubbers from different estates ranged from 0.36 to 1.07 and stated that the smoke number of good smoked sheet should be between 0.5 and 0.75. Somewhat higher values than the above have been found, the value in the case of heavily smoked sheet being over 2.0. It was observed that whereas thoroughly dried sheets of lower smoke values gained in weight on exposure to the air sheets of higher smoke values lost weight owing to the loss of volatile smoke bodies.

(b) PACKING OF SHEET RUBBER

The increase in the export of baled rubber has necessitated consideration of the methods of packing rubber with special reference to packing materials and the best means of packing. Requests have been made and agreed to that the Institute should co-operate in trials with a new form of packing material.

(c) STORAGE OF SHEET RUBBER

The early part of the year, being a period in which a low release only was allowable, was responsible for many inquiries relating to the prevention of mould on sheet. The advisability of using paranitrophenol has been questioned by some consumers even for the prevention of mould on smoked sheet. A number of other bactericides have been examined therefore but none is considered so far to be as satisfactory as paranitrophenol; this investigation is being continued. Packing case materials have been subjected to mould tests in order to ascertain their liability to affect the rate of mould formation.

Advisory Work and Routine Chemical Examinations

The tendency of the advisory work to increase in volume, which has been observed in recent years, has continued and this has entailed increasing demands on the time of the Staff, particularly of the officer who deals primarily with advisory work. The appendix to the Director's report gives an analysis of the correspondence of the Division from which it will be observed that 931 letters were received and 1,356 letters were despatched.

The nature of the inquiries has varied throughout the year and has been influenced by the prevailing political circumstances. In the early part of the year when estates were allowed to store a proportion of their output many inquiries were received regarding the conditions of storage of sheet rubber, prevention of mould and defects on smoked sheet generally. Numerous inquiries particularly in the first part of the year concerned latex and latex concentration. On the outbreak of war inquiries decreased considerably for a brief period, a waiting attitude being noticeable but after taking stock of the position interest is now again being turned in the direction of latex problems. The position as regards coagulants has been referred to already in another section of this report. Apart from the brief period following the commencement of hostilities, interest in the Tunnel smoke-houses has continued to increase and 69 plans and drawings have been distributed during the year to estates, contractors, agency houses and others.

Nearly 700 samples and specimens were received for examination in the laboratory; this is a substantial increase over the number examined last year which in turn was substantially in excess of that of the previous year. The year's increase is partly accounted for by the number of materials sent in for examination as potential coagulants. During the year 393 estate managers and other visitors were received in the Division and 111 visits were paid to estates by members of the staff. These numbers represent increases over those of the previous year.

Twenty tours of an advisory nature were made during the year principally to Johore and Kedah.

Collaboration with Allied and Other Organisations

Collaboration has been maintained throughout the year with our colleagues of the London Advisory Committee and the Ceylon Rubber Research Scheme with whom interchanges of progress reports have taken place regularly and upon which comments and criticisms have been offered and accepted. By this means each organisation is kept fully informed of the activities of the other organisations. Samples of any promising materials evolved during the year have been sent to the London Advisory Committee for examination. Contact has also been maintained with the British Rubber Producers' Research Association.

During the year we received a visit from two A.V.R.O.S. Chemists, Messrs. Van Dillen and Schrieke, who spent a week in Malaya visiting the laboratories, Experiment Station, estates and rubber factories. Although the time was all too short for a comprehensive programme of the nature outlined they were able

to see things and discuss matters of mutual interest and to take away with them typical impressions of Malayan plantation activities.

Co-operation with the Crude Rubber Committee of the American Chemical Society has continued. The writer was able to be present at the meeting of the Rubber Division group held at Baltimore in the Spring and was invited to attend the meetings of the Crude Rubber Committee at which matters concerning latex and rubber testing were under discussion, including final amendments to the latex specification which has been published recently. As a result of this meeting considerable progress was made in the direction of a unification of the British and American methods of testing latex. The writer was able to see also something of the many manufacturing activities and I must take this opportunity of thanking those who did so much to make the visit both pleasant and profitable. Notes on the visit have been published in the *R.R.I. Planters' Bulletin*, No. 8. The Centenary meeting was held at Boston in the Autumn, when selected papers dealing with different aspects of vulcanisation were presented. One paper was scheduled to deal with the plantation industry and the Institute was honoured by being invited to give this paper. This invitation was accepted and a paper by Mr. Hastings and Dr. Rhodes was submitted. Arrangements were made for Mr. Piddlesden to travel via America en route to England on leave, to enable him to represent the Institute at the Boston meeting and to see also some of the American manufacturing activities.

We wish to express our gratitude to organisations in Malaya with whom our work brings us into contact including the Research Department of Socfin Co., Ltd., the B. F. Goodrich Research Station, Shum Yip Leong Ltd., and Wilkinson Process Rubber Co., Ltd., all of whom we have found to be extremely helpful in co-operating in experiment work and willing to place any facilities at our disposal. Finally we would like to thank the managements of estates who are always ready to assist us in the preparation of samples and in many other ways; this assistance is greatly appreciated.

Lectures

The following lectures were given during the year:—

<i>Lecturer</i>	<i>Place</i>	<i>Title</i>
W. S. Davey	... Incorporated Society of Planters, Malacca Branch, at Jasin	"Synthetic Rubber."

W. S. Davey	...	Rotary Club, Kuala Lumpur	"Synthetic Rubber."
J. D. Hastings	...	Incorporated Society of Planters, Nilai-Labu Branch, at Nilai	- do. -
J. D. Hastings	...	Incorporated Society of Planters, Seremban—Rantau—Port Dickson Branch, at Rantau	- do. -
J. D. Hastings	...	Incorporated Society of Planters, South Johore-Riow Branch, at Johore Bahru	- do. -
V. H. Wentworth	...	Estates Asiatic Staffs Association, Malacca, at Malacca	"From Raw Rubber to the Manufactured Article."
V. H. Wentworth	...	Incorporated Society of Planters, Central Kedah, at Sungei Patani	- do. -
V. H. Wentworth	...	Incorporated Society of Planters, Kajang Branch, at Kajang	- do. -
V. H. Wentworth	...	Conference of Asiatic Rubber Instructors at the Institute	- do. -
K. C. Sekar	...	Selangor Estates Asiatic Staffs Association at Kuala Lumpur	"Latex Concentration with Particular Reference to Creaming."

Publications

Journal of the Rubber Research Institute of Malaya

Communication	236	Wentworth: The Softening of Rubber—Part I
"	237	Hastings: The Softening of Rubber—Part II
"	238	Rhodes: Variation in the Composition and Properties of Fresh Latex
"	241	Rhodes & Fairfield Smith: The Viscosity of Preserved and Concentrated Latex—Part I
"	242	Rhodes: The Viscosity of Preserved and Concentrated Latex—Part II
"	243	Hastings & Rhodes: The Effect of Variability of Rubber on Vulcanisation

R.R.I. Planters' Bulletin

No. 1—Storing Sheet Rubber

No. 4—Concentrated Latex Prospects

No. 5—Ventilation of R.R.I. Smoke-house

No. 7—Latex Coagulants

No. 7—Supplies of Estate Chemicals

No. 8—Coagulants

No. 8—Rubber Manufacturing Industry of the United States

Circular No. 8—The use of Serum for Coagulation of Latex

„ *No. 9*—Coconut Water as a Coagulant for Latex

Malayan Agri-Horticultural Show

There was no Institute exhibit at the show ground but as in 1938 the Institute was open to the public. Officers and assistants of the Chemical Division were on duty for discussion and demonstration of apparatus to those interested.

Mr. Davey and Mr. Wentworth acted as judges with Mr. Moore and Mr. Meikle in the All-Malayan Smallholders Rubber Competition. The judging was carried out at the Institute and the exhibits were displayed at the Show.

W. S. DAVEY

Head of Chemical Division

Kuala Lumpur,

29th March, 1940.

ANNUAL REPORT CHEMICAL DIVISION

INDEX

	Page
Concentrated latex, increased demand for	196
Containers for latex, filming	199
Creaming agents	201
Coagulants shortage and alternatives	210
Discoloration of latex	198
Dyestuff no. 37914 as a preventive of discoloration	198
Dowicide G	200
Drying rubber	212
Flavines as preventives of discoloration of latex	198
Filming of containers for latex	199
 Latex:	
increased demand for concentrated latex	196
specification for testing	197
sludge	197
"ROTOJECTOR" machine	197
discolouration	198
flavines as preventives of discoloration	198
filming of containers	199
preservation by Spence's method	199
" " Santobrite (or Dowicide G, Uniexol G)	200
" " chlorphenates	200
concentration (creaming) by "Manucol"	200
" " " Schisa gum	201
creaming agent solutions, preparation	201
centrifuging with different makes of machines	203
de Laval centrifuging machine	203
Manucol	200
Modified rubbers	204
Peptising agents	204
Plasticity:	
plasticity of clonal rubber	209
plasticity and latex constituents, relationship	210
Packing sheet rubber	213
"ROTOJECTOR" machine for de-sludging latex	197
R.P.A. no. 2 & no. 3	204
Sludge in latex	197
Spence's method of preservation of latex	199
Sodium pentachlorophenate (Santobrite)	200
Schisa gum	201
Sharples centrifuging machine	203
Softened rubber	204
Soft rubber	209
Smoke-houses	212
Storing sheet rubber	213

ANNUAL REPORT OF
EXPERIMENT STATION

ANNUAL REPORT *

EXPERIMENT STATION

Acreage Statement

Planted	...	...	...	1,184.66 acres
Gardens and cleared land	...	...	...	14.00 "
Building sites and Roads	...	...	...	66.18 "
Elephant belt	{	...	...	86.66 "
Reserve jungle				
				1,351.50 acres

Details

In bearing on 31.12.1939	...	...	...	774.78 acres
Immature including Nurseries	...	...	...	409.88 "
Cleared but not planted	...	...	...	4.00 "
Coolies gardens	...	...	...	10.00 "
				1,198.66 acres

Not included in the above statement are two seed gardens totalling 10 acres in the Forest Reserve. These areas are held under permit and are reserved for work on *Hevea spruciana*.

Distribution of Land

Botanical Division	...	...	...	876.08 acres
Soils	...	...	...	258.58 "
Pathological	...	...	...	16.00 "
Chemical	...	...	...	34.00 "
				1,184.66 acres

Botanical Division Areas†

NEW CLEARINGS 1939—*Field 38*. (See Plates V & VI, opposite)

Fifty-nine acres of virgin jungle were opened without being burnt off and were planted with unselected seed for use in future Botanical Division Experiments.

* An index follows page 238.

† Areas called "Fields" in this Report were called "Blocks" in the Experiment Station Report for 1938.



PLATE NO. V.

R.R.I. Experiment Station. "No Burn" Clearing
Photographs taken on



PLATE No. VI.

(Field 38). (See pages 218 and 219).
13th September 1939.

With the main object of preventing exposure of the soil, felling was left until the last moment and all possible preliminary work was completed before felling. This meant in effect that all work except clearing of felled trees and undergrowth and planting had to be carried out in the standing jungle. No practical difficulty was experienced in any of this work with the exception of the contour lining. This was essential owing to the steepness of the land; the denseness of the jungle prevented vision of one line from the next, rendering correct lining a difficult proposition.

A rentis was cleared to three feet each side of each contour line; all surface timber was cleared and slewed on the lower slopes into the standing jungle and stacked on the contour to arrest erosion. Trees on the cleared rentis to a diameter of 8 inches were cut off at ground level. Larger trees were left for the final felling.

Lining pegs were put in along the cleared rentis at intervals of 10 feet.

Stumps to a diameter of 8 inches which interfered with the planting points would normally have been eradicated following the lining, but labour shortage postponed this work until 1940.

Lalang and all other undesirable plants were eradicated before felling while there was still heavy shade.

Individual platforms four feet square with a slope into the hill side were cut and planting holes were dug and filled.

Finally, a few weeks before the *Hevea* seed-fall was expected to commence, the jungle was contour-felled and the planting rows cleared of fallen timber.

Germinated seeds, protected by various types of mechanical rat-guards, were planted out at the rate of three seeds per hole. Hollow four-inch bamboo guards gave excellent protection from rat attack but were of little value against squirrels. Considerable supplying was necessary and well-grown basket plants painted with the recommended "Tanglefoot" mixture were used for this purpose.

The most important point learnt from this method of opening is the necessity for retaining large nurseries of basket plants and/or stumps for supplying plants damaged by pests.

The costs for the first year of opening this field are shown in the table on the next page.

Five rounds of weeding followed the felling and clearing. Weeding is a loose term in the sense that it includes control of noxious growths on and between the terraces, eradication of all creepers and beating of attaps.

Work	Type of Labour	Method of payment	Total Cost	Cost per Acre
Soil profile pits and rentises for preliminary inspection ...	Tamil	day pay	\$ 2.34	\$.04
Lining before clearing ...	Malay	"	199.20	3.38
Clearing 6 ft. strips ...	Tamil	task work	463.26	7.85
Lining after clearing ...	Malay	day pay	23.89	.40
Supervision paths 6 ft. wide ...	Tamil	"	80.52	1.36
Prefelling drainage ...	Malay	contract	88.66	1.50
Cutting 4 ft. platforms ...	Tamil	task work	289.72	4.92
Weeding (5 rounds) ...	"	day pay	379.96	6.44
Lalang (5 rounds) ...	"	"	31.21	.53
Watchmen for fire ...	"	"	38.02	.64
Nurseries ...	"	"	53.86	.91
Holing and filling ...	Malay	task work	85.02	1.45
Felling ...		contract	735.00	12.46
Clearing 6 ft. strips after felling ...	Chinese	"	910.60	15.44
Felling dead trees ...	Tamil	day pay	43.90	.74
Fencing (in part only) ...	"	"	26.11	.44
Planting and supplying ...	"	"	126.93	2.15
Pests (provision of rat guards) ...	"	"	211.49	3.58
			\$3,789.69	\$ 64.23

NURSERIES

Clones of which budwood was no longer required were eradicated from the main multiplication nursery and replaced by budded stumps of newer clones, and seedlings to be budded later.

All nurseries containing valuable material were manured at set intervals with liquid cowdung and light applications of an inorganic fertilizer.

Eight acres of jungle, felled in 1928—29 to form an elephant belt and allowed to regenerate, were again felled in August 1939 and burnt off in September 1939 to form a new nursery. Preparation of this nursery was expensive as insufficient time had been allowed for drying and decay of the felled timber and the burn was consequently incomplete. Large patches of sheet lalang gave further difficulty.



(1) 15th March 1938.



(2) 29th September 1938.

PLATE No VII.

"Light-Burn" Clearing at R.R.I. Experiment Station (Field 34).
 Photographs taken from the same spot: (1) 1 month after burning;



(3) 29th September 1939.



(4) 19th April 1940.

PLATE No. VIII.

Felled January 1938. Planted September 1938. (See page 221).

(2) at planting; (3) 1 year after planting; (4) 1 year 7 months after planting.



(1) 15th March 1938.



(2) 29th September 1938.

PLATE No. IX.

"Light-Burn" Clearing at R.R.I. Experiment Station (Field 34).
 Photographs taken from the same spot: (1) 1 month after burning;



(3) 29th September 1939.



(4) 19th April 1940.

PLATE No. X.

Felled January 1938. Planted September 1938. (See page 221).
 (2) at planting; (3) 1 year after planting; (4) 1 year 1 month after planting.

The operations involved and the cost per acre were as follows:—

Felling	...	...	...	...	\$ 8.00
Burning	...	...	...	...	1.00
Clearing all surface timber and stumps to 3 ft. depth	...	...	...	...	40.00
Digging over to 2 ft., removing woody material and eradicating lalang	...	...	...	...	45.00
Levelling and preparing beds	...	...	...	...	20.00
Bunding	...	...	...	...	3.85
Planting and supplying 2 ft. × 2 ft. (4 ac. only)					3.68
					\$121.53

Three acres of the area have been planted with unselected seedlings to form an extra multiplication nursery, and one acre with clonal seedlings.

The remaining four acres, originally intended for the use of the Botanical Division, are now to be utilized for the multiplication of budwood for supply to small-holders under the Small-holders' Advisory Service. This area had a particularly heavy stand of lalang and was accordingly left unplanted until eradication could be considered complete. (It was planted in January 1940).

CLEARINGS 1937—*Fields 32 and 33—63.25 acres*

Seedlings of crosses made by hand pollination in 1937 and grown for two years in the hand-pollination nursery were planted out in October in the centre of Field 33 after eradication of the original unselected seedlings. The remainder of the area containing well-grown seedlings was budded with clones established from these crosses.

In the 1937 clearings natural covers were allowed to regenerate and seeds of bush legumes were sown among the covers. Unfortunately severe caterpillar attack thinned the natural covers, then mainly species of *Trema*. As a result *Tephrosia candida*, which seemed almost immune to attack, became and remains the dominant cover.

CLEARINGS 1938—*Field 34—40.5 acres.* (See Plates VII, VIII, IX and X, opposite)

This area, reserved for establishment of new planting material, contained an even stand of well-grown, buddable, unselected seedlings at the end of 1939. (See Annual Report, 1938, page 169 and 170).

Natural covers had been allowed to regenerate and two rows of *Centrosema pubescens* were sown in contour drills above and

below each terrace. The natural covers regenerated well and were slashed to 5 feet in July. Pestooned in *Centrosema*, they were slow to recover from the slashing but at the end of 1939 there was a fair stand of *Trema* and a few other species. Slashed covers and pulled *Centrosema* were heavily mulched around the young plants and appeared to have a beneficial effect.

Field 35. 30 acres Planted—May 1938. (See Plates XI, XII, XIII and XIV, opposite)

This experiment was started in 1938, on the girdling and poisoning of jungle trees and preparation for planting of *Hevea* with a minimum amount of clearing compared with orthodox methods of felling, burning and planting. The clonal seedling stumps planted in the poisoned jungle at a density of 360 to the acre have shown excellent growth and the majority were buddable at one year from planting. (See Annual Report, 1938, pages 169 and 170).

Falling jungle trees did less damage than might have been anticipated and a good stand of well-grown trees remains after about 50 per cent of the poisoned jungle has fallen. Poisoned trees which showed green leaf after 12 months were felled in October; specimen leaves and branches were sent to the Forest Department for identification of species.

The plots in this experiment opened on orthodox lines and planted with seedling stumps also showed good growth. They were budded in July. Certain rows of trees on the boundary of these plots and outside the experiment proper were budded with material supplied by the Chemical Division. (See also p. 209).

MATURE AREAS

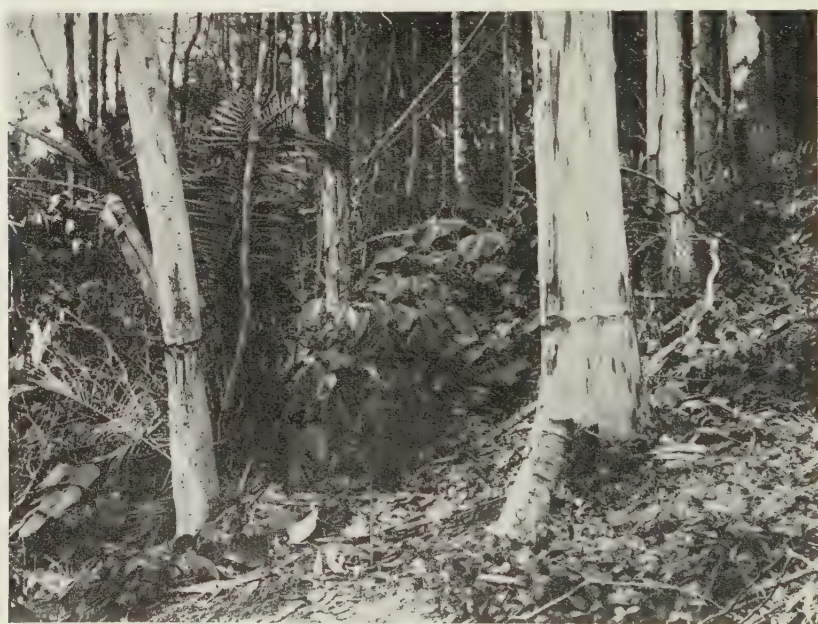
Results from tapping of mature areas can be seen in the Annual Report of the Botanical Division. Areas under control of the Botanical Division now in tapping are summarised below.

288.25 acres	Buddings: duoclone or polyclone
146.50 „	Buddings: monoclone
93.00 „	Seedlings
61.25 „	Mixed seedlings and buddings.
589.00	

Apart from tapping experiments all areas under Botanical Division's control are tapped on the half-spiral alternate-daily system (S/2,d/2,100%).



(1) 15th March 1938.



(2) 29th September 1938.

PLATE No. XI.

Clearing Jungle by Frill-Girdling and Poisoning, without mechanical

Photographs taken from the same spot:

(2) Five months after planting (stumps); (3) One year later;



(3) 29th September 1939.



(4) 19th April 1940.

PLATE No. XII.

felling. R.R.I. Experiment Station (Field 35). (See pages 222 & 147).

(1) When trees poisoned and jungle rentissed ready for planting Hevea;
(4) Two years after planting stumps. (See also Plates XIII and XIV).



(1) 15th March 1938.



(2) 29th September 1938.

PLATE No. XIII.

Comparison of Frill-Girdling and Poisoning, with felling and Light
(See also

Photographs taken from the same spot, showing a "light-burn" area, and a
(2) Five months after planting stumps; (3) One year later;



(3) 29th September 1939.



(4) 19th April 1940.

PLATE No. XIV.

*Burn. R.R.I. Experiment Station, (Field 35). (See pages 147 & 222).
Plates XI and XII).*

poisoned jungle area in the background: (1) One month after light burn;
(4) Two years after planting stumps.

IMMATURE AREAS

Fields of immature rubber trees in which work other than that of a routine nature was carried out, are as follows:—

Field 27. 50 acres Planted—November 1934.

This experiment, described in Botanical Division Annual Report 1938, p. 106, contains five cover treatments replicated five times.

The areas with natural covers under a minimum of control have been divided into two equal parts; in one half the uncontrolled covers were slashed to ground level and mulched between terraces; an attempt was made to grow *Centrosema* over the mulch. In spite of a liberal supply of inoculated seed the *Centrosema* has not yet been established; the second half was left as before under a minimum of control.

In the same experiment the five blocks under a cover of leguminous creepers, which had almost disappeared, were manured with basic slag at the rate of 2 cwt. per acre, broadcast between planting rows (see also p. 146).

Field 26. 10 acres Planted—May 1934

This area of 10 acres containing nine different families of clonal seed was test-tapped in July and thinned-out on the results obtained.

Fields 9A and 20A. 5.25 acres Planted November 1933

These areas of 5.25 acres were test-tapped in July.

Field 20B. 20 acres Planted December 1929 Immature

A field of 20 acres containing 12 blocks of buddings planted in duoclone plots was thinned-out where necessary in October.

SUMMARY OF TAPPING EXPERIMENTS. (See also pp. 99-130)

Field 5. 40 acres Planted in November 1929

This field contains nine clones in monoclonal blocks; three tapping systems are compared:—

S/2,d/1,m/2,100% (Half-spiral tapped daily in alternate months)

S/2,d/2,6m/9,67% (Half-spiral alternate-daily, "ABC" periodic 6 months tapping, 3 months rest)

S/2,d/2, 100% (Half-spiral alternate-daily)

Field 21

A polyclone area of seven clones; the tapping systems employed in 1939 were

S/2,d/1,m/2,100% (Half-spiral tapped daily in alternate months)

S/1,d/4, 100% (Full-spiral tapped fourth-daily)

S/2,d/2, 100% (Half-spiral tapped alternate-daily)

Field 25 Section 5

A height-of-tapping experiment on seedling trees; the treatments compared include opening of initial cut at 20", 30", 40" and 50" from ground level; the tapping system employed is S/2,d/2, 100%.

Field 22A

A height-of-tapping experiment on budded trees; the area is a polyclone block of five clones. The treatment and the tapping system are the same as for Field 25 Section 5, the height of opening being measured from the union.

Field 19A

A single-task tapping experiment in a monoclonal field of Bodjang Datar 5 was started in August 1939. Thirteen different tapping systems are employed in this task. One tapper taps all trees under direct supervision of a Divisional Field Assistant.

The systems used are tabulated on the opposite page.

Field 18C

This area of 20.5 acres containing monoclonal rows of 16 clones mixed with seedlings is to be replanted in the near future.

It now contains a slaughter-tapping experiment with the following systems:—

S/1,d/1, 400% (Full-spiral tapped daily)

S/1,d/2, 200% (Full-spiral tapped alternate-daily)

S/1,d/1,3w/6, 200% (Full-spiral tapped daily for three weeks, followed by 3 weeks rest)

2S/2,d/1,3w/6,200% (Two half-spirals tapped daily for three weeks, followed by 3 weeks rest)

S/1,d/3, 133% (Full-spiral tapped every third day)

S/2,d/2, 100% (Half-spiral tapped alternate-daily)

Cases of brown bast quickly appeared in the task tapped full-spiral daily.

FIELD 19A

Single-Task Tapping Experiment on B.D.5

Treat- ment Number	Tapping System			Relative tapping intensity per cent
1	S/2,d/1,m/2	{	half-spiral daily alternate-monthly	100
2	S/2,d/2		(half-spiral alternate-daily)	100
3	2S/2,d/4	{	two half-spirals tapped fourth-daily	100
4	S/3,d/2		(third-spiral alternate-daily)	67
5	2S/4,d/2	{	two quarter-spiral cuts alternate-daily	100
6	S/2,d/2,10m/12		half-spiral alternate-daily, ten months tapping and two months rest	± 83
7	S/2,d/2,6m/9		half-spiral alternate-daily; six months tapping and three months rest	67
8	S/2,d/1,1m/1½	{	half-spiral daily, one month tapping and half month rest	150
9	S/2,d/3		(half-spiral third-daily)	67
10	S/1,d/3		(Full-spiral third-daily)	133
11	S/1,d/3,3m/4		Full-spiral third-daily, three months tapping and one month rest	100
12	S/1,d/4		(Full-spiral, fourth-daily)	100
13	S/1,d/4,10m/12		Full-spiral, fourth-daily; ten months tapping and two months rest	± 83

BOTANICAL DIVISION, GENERAL

Export of Budwood and Clonal Seed

Large quantities of budwood and clonal seed were despatched to experimental areas in all parts of Malaya. In all 11,484 yards of budwood and 18,471 seeds were despatched.

Root Studies

Root study of clonal seedlings and buddings and similar work was carried on by Dr. Baptist in Fields 6 A and 4 B and labour for this purpose was provided when necessary. (See also p. 86).

Hand Pollination Work

Artificial hand pollination of chosen clones continued under the control of Mr. C. C. Sharp. Scaffoldings for this purpose were erected in various parts of the Station.

It was found possible to train 12 Tamil "podians" of an average age of 14 years to do mass pollination between two chosen clones. (See also p. 132).

Sample Collection

From May 1939 it was decided to reduce the number of individual cup coagulations in many Botanical Division Fields from daily to twice-monthly coagulation. This has eased the congestion in the samples-drying shed and has increased Experiment Station revenue by lowering the proportion of lower grades.

Measurements

Girth measurements were taken by Botanical Division Assistants in all fields with the assistance of Experiment Station labour. Trees in all fields reaching maturity were stencilled with field, row and tree number; stencil marks were renewed where necessary.

Soils Division Areas

MANURIAL TRIALS

Field 6. 40 acres Seedling Trees

Treatments

Amounts

Control—unmanured

Organic

56 lb. cowdung per tree.

Complete inorganic

2½ „ "Enpekay" No. 1 per tree.

Nitrogen

2 „ sulphate of ammonia per tree.

Nitrogen and Phosphate

2 „ "Nicifos B" per tree.

Potash and Phosphate

1¾ „ mixture (sulphate of potash and double superphosphate per tree.

All fertilisers were applied in 8 ft.- wide forked strips between tree rows. The control unmanured plots were similarly forked.

Field 36

A two-acre nursery was laid down in September 1938 as an experiment to ascertain (a) the effect of manure on budding successes, when applied at varying times before and after bud-grafting (b) the effect of manures on nursery budwood.

The stock nursery consists of 96 plots in factorial lay-out containing 171 plants per bed; the budwood nursery consists of 24 plots containing 171 budded stumps per bed.

Three applications of fertilizer were given at three-monthly intervals in 1939; it is anticipated that one further application in 1940 will be necessary and that the stocks will have reached buddable size in April. (See also p. 72).

Field 13A. 2½ acres. Replanted November 1936—Budded with Tj. 1 in October 1938

- A. Plots received 6 oz. "Enpekay" No. 2 per tree in April.
- B. " " 6 " "Enpekay" No. 2 " "
- C. " " 6 " Complete inorganic (special mixture).
- D. " " 6 " "Enpekay" No. 2 per tree.

Field 17D (N)

A small manurial trial on a patch of very poorly-grown clonal seedlings, in which the potash deficiency has shown up very clearly.

- A. Plots Control. No manures.
- B. " 19 oz. sulphate of ammonia per tree in April and October.
- C. " { 19 " sulphate of ammonia per tree in April and October.
22 " superphosphate per tree in April and October.
- D. " { 19 " sulphate of ammonia per tree in April and October.
10 " sulphate of potash.
- E. " { 19 " sulphate of ammonia.
22 " superphosphate per tree in April and October.
10 " sulphate of potash.
- F. " 22 " "Nicifos" B.
- H. " { 19 " sulphate of ammonia per tree in April and October.
16 " ground lime.

Full details are given in R.R.I. Annual Report 1938 page 178. No further applications of phosphate were made in 1939. The cover is still weak but is improving in certain plots.

Field 25. 35 Acres. Seedling trees planted December 1930

A cover-crop trial containing replicated plots of grasses, leguminous bushes and creepers. The bush covers were slashed according to schedule.

Field 19. Cultivation experiment. Planted—November 1929

The work of digging-in grasses etc. in the demarcated plots was carried out twice according to routine. It is noticeable that *Mikania* has to a great extent replaced the original Red Natal grass in cultivated plots.

Measurements

Girth measurements were taken in all Soils Division fields at set intervals by Divisional Assistants. Labour for the purpose was supplied by the Experiment Station.

Leaf Analysis

Leaf collection for analysis under the supervision of Research Officers continued in manurial and clone trials with the help of Experiment Station labour.

Pathological Division Areas

Routine inspection and treatment for all diseases were carried out during the year over the whole Station.

Summary of Work Done

	<i>Trees treated</i>	<i>Trees removed</i>	<i>Total</i>
<i>Fomes lignosus</i> ...	1,799	389	2,188
<i>Ganoderma pseudoferreum</i> ...	251	126	377
<i>Fomes noxius</i> ...	147	71	218
<i>Ustulina zonata</i> ...	104	45	149
Termites ...	3,092	89	3,181
Pink disease ...	1,239	—	1,239
	6,632	720	7,352

The treatment of root disease remained the same as in previous years.

Fields 7 and 8. Seedling trees planted December 1928. 20 acres

In this area trees infected in the root system by *Ustulina zonata*, *Fomes noxius* or *Ganoderma pseudoferreum* are inspected at regular intervals, but not treated. The limits of spread of infection at successive inspections are marked by bands of coloured paint.

Field 11. Seedling trees planted February 1929. 10 acres

An experiment started originally to determine the incidence of root disease under so-called "Kampong" conditions.

In one third of the area natural covers have been allowed to grow unmolested since planting, being slashed away only when they actively interfered with the growing tree.

In another third natural covers are permitted to grow right up to the trees but have been kept slashed annually to 4 feet to 5 feet.

The remaining third consisted originally of equal parts of the first and second treatment. In 1933, however, the covers in this plot were eradicated, and from then on the plot has been cleaned-weeded.

In 1935 the areas under natural covers were rentised to permit of access for tappers and tapping commenced in July 1935.

The incidence of root disease has been negligible over both areas under natural covers, and normally prevalent in the cleaned-up area.

Termite attack has been considerable over the whole area.

The *Yields per acre* for the various treatments are:—

Treatment		Planting Distance	Yield per acre			
			1936	1937	1938	1939
			lb.	lb.	lb.	lb.
Cleaned-up area	...	22' × 11'	593	673	560	786
"	...	22' × 22'	330	396	387	588
Slashed area	...	22' × 11'	525	623	505	699
"	...	22' × 22'	316	390	366	529
Unslashed area	...	22' × 11'	415	589	521	705
"	...	22' × 22'	247	391	388	539

Tapping started on 1-7-35 at 22 inches S/2,d/2,100%.

Cuts turned over on 1-1-38 at 30 inches.

SULPHUR DUSTING

There was no attack of *Oidium* during the year, but four rounds of sulphur dusting with the power machine were given to control attacks of thrips, mites and other insect pests.

Trees needed for hand-pollination work were dusted weekly throughout the flowering season.

All nurseries were dusted weekly throughout the year, a hand machine being used for this purpose.

CATERPILLARS

Very little damage was done as compared with previous years. There was a mild attack in one of the 1938 clearings which was quickly controlled by spraying of covers with a 1½ per cent solution of lead arsenate.

TERMITES

The four methods in use in 1938 remained unchanged. These are outlined in *R.R.I.E.S. Annual Report 1938* p. 182. (See also p. 183).

PHYTOPHTHORA

This disease appeared for the first time on the Experiment Station in November on the stems of young seedlings in the new clearing. The disease was apparently encouraged by the use of paper cylinders as rat guards. The paper got very wet in the heavy rains and remained sodden over a long period, effectively enclosing the young plant in a continuously damp atmosphere. The papers were replaced by bamboo cylinders and the *Phytophthora* did not recur.

Field 37.

This area of 8 acres planted in 1938 with unselected seedlings at a density of 871 per acre has been used by Pathological Division as a testing ground for various chemical dusts and sprays.

Chemical Division Experiments

COAGULANT SHORTAGE. (See also p. 210)

Under instruction from Research Officers of the Chemical Division much experimenting was done on the use of serum as a coagulant. The chief difficulty encountered was to obtain sheet free from bubbles, but after a few trials on a factory scale satisfactory sheet was prepared.

Various other substances including tamarind and superphosphate extracts were also tried as coagulants. The chief difficulty, especially in the case of tamarind, was to obtain a sheet free from bubbles. Specimen sheets coagulated with these and other substances are on view in the Experiment Station packing shed.

For some time one gallon of fresh toddy was sent daily to the laboratories for test as to its value as a coagulant.

EXPERIMENTS ON THE PROPERTIES OF CLONAL AND SEEDLING LATICES

Sheet prepared from latex obtained from seedling and budded rubber trees by various systems of tapping was supplied to the Chemical Division.

SMOKE-HOUSES

The new Tunnel type "A" Smoke-house was built during the year and is functioning excellently.

Experiment Station, Routine and General

1. NEW ROADS

Thirty-one chains of new road were constructed in continuation of the 1938 road programme. When this road is completed in 1940, it will circle all areas to the south of the Government Road, starting at the main Experiment Station entrance and finishing at the 17th mile Subang Road. It will be of great value for supervision purposes and for escort of visitors.

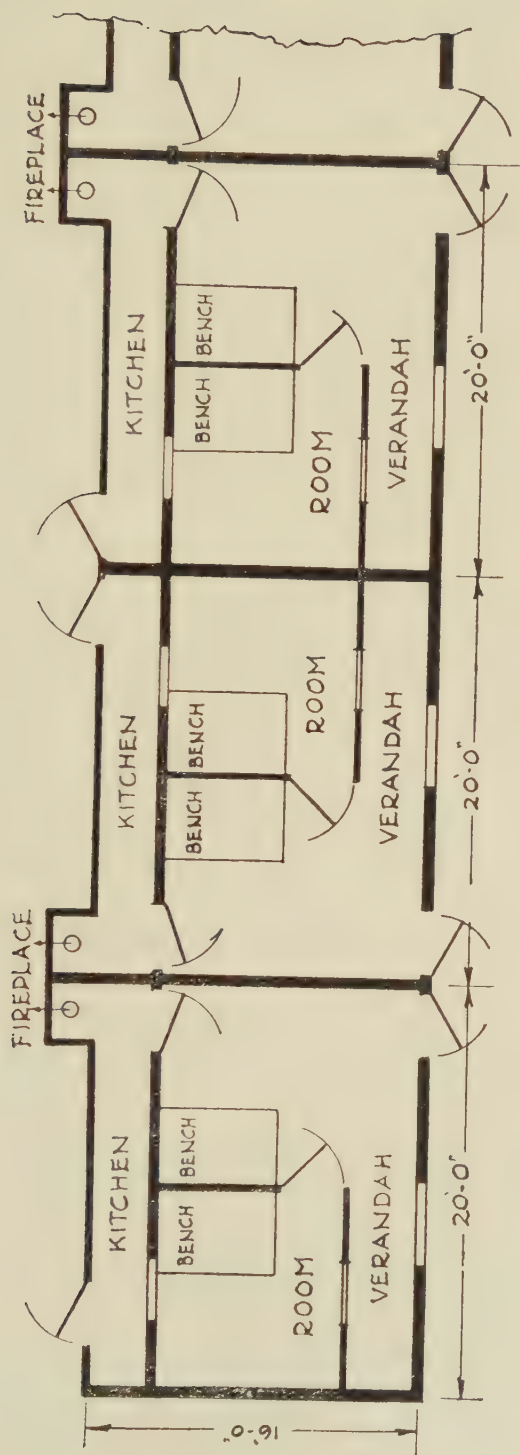
Five permanent hardwood bridges were built to replace temporary structures.

2. DRAINS

Owing to the light sandy nature of the Station soil continual difficulty from breakage of the banks of the anti-malarial system of drains has been experienced. In an effort to cope with this difficulty a system of bunding and canalizing was tried out over a distance of 20 chains. Results are so promising that large-scale trials will be made in 1940.

3. BUILDINGS

Four sets of five-roomed cooly lines of a type suggested and approved by the Controller of Labour were erected. Each house in these lines has a floor dimension of 20' x 16'; the main room is partitioned to form two separate bedrooms and each house has enclosed kitchen and verandah. Ventilation is excellent. This type is proving very popular with the labour. The ground floor plan is shown opposite.



One new brick bungalow with tiled roof was provided for Junior Staff.

A large permanent building previously occupied by Chinese has been partitioned into bedrooms for the use of visiting conductors who are attending courses of instructions.

4. WATER SUPPLY

Owing to the severe drought the dam in the jungle, from which the main water supply is drawn, dried up completely and over a period of six weeks water was carted by lorry for the use of factory, lines and bungalows.

Work on an auxiliary water supply formed by damming the Sungei Pelan was started in August but was held up owing to shortage of piping in Malaya. (This piping was in fact obtained early in the new year and the new supply should obviate any possible future shortage.)

5. RAINFALL

The rainfall during the year was 74.21 inches, the lowest ever recorded on the Experiment Station.

6. ROUTINE WORK

Tapping

There was no tapping on 16 days owing to holidays.

 " " 8 " rain.

 " late " 69 " "

Rain interfered with tapping on 16 other days.

Upkeep Works

Weeding, slashing and patrol for lalang continued as in past years. Lalang patrol is necessarily more intensive where natural covers are present.

Little repairing of terraces was necessary in our mature, hilly areas, proving the efficiency of the original reverse "V" type terrace. Considerable repairs to bunds were necessary in immature areas which had been square- and not contour-planted.

The main road system was resurfaced where necessary.

7. MANUFACTURE, EXPORT AND REVENUE

The F. E. Major sheeting battery installed in 1936 continued to give excellent service. Two new all-metal tanks are proving very satisfactory.

Details of crops despatched for sale in Kuala Lumpur are as follows:—

R.S.S.	...	...	...	221,993 lb.
Compo	...	...	...	30,200 „
Crepe	...	...	...	3,390 „
Cup lump	...	...	...	131,997 „
Total				387,580 „

A revenue of \$104,513/45, was obtained from the sale of rubber in 1939.

With increased crops and probability of an enhanced average price, there is every reason to believe that the Experiment Station will have a surplus of revenue over expenditure in 1940.

8. LABOUR FORCE; MEDICAL AND HEALTH

Health during the year has been good.

There was however an increase in the incidence of malaria, the cause of which was traced to Chinese felling operations in the nearby Forest Reserve. Clearing of the jungle has opened to the sun large patches of malarious swamps.

An attempt has been made to drain all dangerous areas but, even with continuous oiling, such *Anopheline* breeding grounds cannot be wholly controlled.

Details of Labour and Health

Workers			Dependants		
Men	...	170	Men	...	4
Women	...	106	Women	...	10
Children	...	35	Children	...	92
311			106		

	Admissions to Hospital		Treated on Experiment Station	
Malaria	...	Nil		17
Injuries etc.	...	5		110
Confinements	...	16		Nil
Deaths	...	4 (2 infants and 2 adults)		

Average spleen rate for the year

Men	...	...	...	1.40%
Women	...	...	...	1.02%
Children	...	...	...	1.72%

Labour

There was a shortage of Tamil labour during the year, caused only by lack of accommodation. This was remedied as soon as the new lines were completed.

A request was received from the Tamil "Panchayat" to the effect that the Station toddy shop should be closed. A secret ballot was held among all adult male labourers with the result that 89 per cent voted against and only 11 per cent for continuation of the sale of toddy. The shop was accordingly closed on Sept. 30th, 1939.

9. REFRESHER COURSES

During the year three Europeans and 66 estate conductors were given instruction in modern methods of estate practice for periods of from 2 to 10 days each.

Refresher courses for estate conductors are proving increasingly popular and facilities for a greater number of courses will be given in 1940.

A course of instruction in field and factory practice lasting four weeks was given to Asiatic Rubber Instructors newly engaged by the Institute.

10. VISITORS

During the year a total of 524 visitors were shown round the Experiment Station. This shows a small increase on the previous year.*

Parties from the Nilai-Labu and Lower Perak branches of the Incorporated Society of Planters visited the Station.

We also welcomed the visit of the Kuala Lumpur branch of the Estate Asiatic Staffs' Association.

11. STAFF

The staff employed at the Station comprised:—

Europeans

H. W. Foston (January—May)

T. N. Dickson

R. F. Harley

*The figure of 725 given in the 1938 Report inadvertently included 215 visits by Research Officers of the Institute Staff, the corrected figure for 1938 thus being 510.

Mr. Foston retired from his position as Manager, Experiment Station, in May 1939. Mr. T. N. Dickson, Assistant Manager, was appointed Manager from June 1st in his place. Mr. R. F. Harley, Assistant, was appointed Assistant Manager, from the same date. The writer would like to place on record the appreciation of all staff for the sympathy and help invariably extended by Mr. Foston during his ten years management. Mr. J. H. Tovey was appointed Assistant, Experiment Station in October (and assumed duty in January, 1940.)

Experiment Station Staff

- 1 Chief Clerk
- 1 Asst. Clerk
- 1 Typist
- 1 Dresser
- 1 Field Conductor
- 1 Tapping Conductor
- 1 Factory Clerk

Headquarters Staff

- 1 Senior Botanical Division Assistant
- 8 other " " "
- 1 Soils " "
- 2 Pathological " "
- 2 Chemical " "
- 1 Asiatic Rubber Instructor

I have to record with appreciation the loyal assistance given by the staff during the year and particularly during the difficult period when the European staff was short of complement.

12. LECTURES AND VISITS

Lectures on "Replanting" and "New planting from Jungle" were given by all European staff on the Station.

<i>I.S.P. or D.P.A.</i>	<i>Subject</i>	<i>Lecturer</i>
1. Kelantan I.S.P.	Practical features of New Planting and Replanting.	} H. W. Foston
Central K e d a h I.S.P.	Practical feature of New Planting.	
Nilai-Labu I.S.P.	- do -	- do -
2. Penanag and Province Wellesley D.P.A.	Practical features of Replanting.	} T. N. Dickson
Kuala Selangor D.P.A.	- do -	
Central Pahang Planters' Association.	- do -	- do -
3. Lower Perak I.S.P.	Practical features of New Planting.	} R. F. Harley

Mr. Foston carried out a tour of experimental areas in Kelantan and Kedah. Mr. Dickson and Mr. Harley visited various estates in Selangor. Visits to the experimental areas had to be severely curtailed in the latter half of the year owing to shortage of staff but it is hoped that these will be resumed in 1940.

13. ACKNOWLEDGMENTS

Our thanks are due:—

1. To the Controller of Labour, Malaya, for his assistance with regard to a choice of plan for our new Tamil lines.

2. To Mr. A. V. Beith, General Manager, Kepong (Malaya) Rubber Estates Ltd., for permitting us to show visitors round replanted areas belonging to his Company and for other assistance freely given.

3. To our Visiting Medical Officer, Dr. I. G. Cameron for his untailing advice and assistance.

4. To Mr. A. C. McCaul, Manager of Seventh Mile Estate for permission to study and copy his system of anti-malarial drainage.

T. N. DICKSON,

Manager

Sungei Buloh,

March 1st, 1940.

ANNUAL REPORT
EXPERIMENT STATION

INDEX

	Page
Acreage	218
Budwood, export	225
Buildings	232
Coagulants, shortage and alternatives	232
Caterpillars	231
Clearings 1939	218
Clearings 1937—8	221
Clonal seed, export	225
Cup-coagulation of samples	226
Crop of rubber	235
Courses, refresher, for Conductors	236
Distribution of land by Divisions	218
Diseases, summary of work	229
Drains	232
Hand pollination	226
Health of labour	235
Labour, health	235
Lectures	237
Manurial trials	226
Nurseries	219
Nurseries for multiplication of budwood	221
Opening jungle without burning	218
Opening jungle without burning, costs	220
<i>Oidium</i>	231
Poisoning jungle trees	222
<i>Phytophthora</i> disease	231
Refresher courses for Conductors	236
Root studies	226
Root diseases, inspections	230
Root diseases in areas under "Kampong" conditions	230
Roads	232
Rainfall	234
Revenue from sales of rubber	235
Sulphur dusting	231
Smoke-houses	232
Staff	236

						Page
Tapping experiments	...	...	...	...	...	223
Termites	...	...	...	...	...	231
Tapping days lost	...	...	...	...	...	234
Toddy shop closed	...	...	...	...	...	236
Upkeep of planted areas	...	...	...	...	...	234
Visitors	...	...	...	...	...	236
Visits to estates	...	...	...	...	...	238
Water supply	...	...	...	...	...	234

ANNUAL REPORT *

SMALL-HOLDERS' ADVISORY SERVICE

Supervision and Organisation

During 1939 the gradual expansion of the Small-holders' Advisory Service was continued, as in recent years, by the appointment of several new Asiatic Rubber Instructors direct from the School of Agriculture, Malaya at Serdang, Selangor, and others who had previously attended that School. Major tours of inspection to all States and Settlements, except Brunei and Labuan, were carried out by the writer, while in addition parts of Negri Sembilan, Malacca, Johore and Pahang were periodically visited by the Personal Assistant to the Director (Mr. Moore). The latter, on account of ill-health during the fourth quarter, unfortunately could not carry out a proposed tour to the north (Perak, Province Wellesley, and Kedah). Moreover, owing to increasing office work, the writer was unable to complete his provisional programme for the year which included a second tour to Pahang.

The above major tours may be conveniently summarised as follows:—

Quarter	State, Territory, or District Visited		Total No. A.R.Is. visited
	by S.H.A.O.	by P.A.D.	
First	(a) Perak, P. W., Penang, & Kedah. (b) Johore. (c) Kelantan, Trengganu, and East Pahang.	(a) Raub (b) Seremban (c) Johore	24
Second	(a) Malacca and Negri Sembilan. (b) Perak, P.W., and Kedah.	(a) Raub	16
Third	(a) Kelantan and Trengganu. (b) Malacca and Negri Sembilan. (c) Perak, P.W., and Kedah.	(a) Malacca and Rembau (b) Johore (c) Pahang, except East.	27
Fourth	(a) Johore. (b) P.W., Penang, and Kedah. (c) Pahang, except East.		14

* An index follows p. 256.

The number of A.R.Is. visited during the third quarter includes the A.R.I. normally stationed in East Pahang who, however, was temporarily stationed at Kemaman in South Trengganu, at the time the tour to Kelantan and Trengganu was carried out. As in 1939, A.R.Is. in Selangor were visited periodically throughout the year as opportunity occurred while two of them attended the Institute and Experiment Station regularly.

It has therefore been possible to visit most A.R.Is. in the field at least three times with the exception of those on the East Coast and in Brunei who must of necessity be visited less often on account of the difficulty, expense, and time required in travelling to and through those places. This increased personal contact has continued to show good results.

Unfortunately this personal contact between the Asiatic Rubber Instructors and the Institute will not be possible to the same extent during 1940 when, owing to Mr. Moore's absence on home leave, only one officer will be available for this purpose, and since the writer has been appointed to act as Personal Assistant to the Director, long tours will not be possible. It will not therefore, be possible to visit Brunei, and only one tour to the East Coast is envisaged. It is hoped however that most of the other A.R.Is., with whom contact is easier, will each be visited three times during 1940.

Our sincere thanks are once again due for the invaluable help given by the Department of Agriculture and its Field Officers in the various States, Districts, and Settlements, under whose immediate supervision the A.R.Is. work.

ASIATIC RUBBER INSTRUCTORS (A.R.Is.)

At the beginning of May seven new A.R.Is. were appointed, namely, three Malays, three Chinese and one Indian. One of the Malays had completed the Department of Agriculture Continuation Scholarship course of six months at the Experiment Station, Sungei Buloh, together with four of a six months' Paid Apprenticeship Course on Kirby Estate, Negri Sembilan. One of the three new Chinese Rubber Instructors had left the School of Agriculture in 1937 and worked on estates until his appointment as an A.R.I. The intensive practical training which both these men have thus received prior to their appointment has been very useful to them in their work as Rubber Instructors.

The remaining five came direct from the School of Agriculture, Malaya, at Serdang, at which all seven had successfully completed the Two Years Course. Following the usual course of special training at the Experiment Station they were attached to senior A.R.Is. in the field for a further period of instruction before taking

*Distribution of Asiatic Rubber Instructors**at 31st December, 1939.*

State or Territory	Area of Small-holdings	Asiatic Rubber Instructors				Average area of Small-holdings per A.R.I.
		Malay	Chinese	Indian	Total	
Perak ...	265,988	3	1	1	5	53,198
Selangor ...	143,710	2	1	1	4	35,928
Negri Sembilan	99,213	1	1	1	3	33,071
Pahang ...	80,708	3	1	—	4	20,177
Total F.M.S. ...	589,619	9	4	3	16	36,851
Malacca ...	67,680	1	—	—	1	67,680
Province Wellesley ...	23,384	1	1	—	2	19,322(1)
Penang ...	15,280	Served by P.W. A.R.Is.				—
Singapore ...	19,568	Served by Johore A.R.Is.				—
Labuan ...	1,825	Served by Brunei A.R.Is.				—
Total S.S. ...	127,737	2	1	—	3	35,448
Johore ...	360,759	5	2	—	7	54,432(2)
Kedah ...	96,274	2	—	—	2	49,804(3)
Perlis ...	3,334	Served by Kedah A.R.Is.				—
Kelantan ...	58,271	2	—	—	2	29,136
Trengganu ...	31,653	1	—	—	1	31,653
Brunei ...	8,175	1	—	—	1	10,000(4)
Total U.M.S. ...	558,466	11	2	—	13	44,605
Total MALAYA ...	1,275,822	22	7	3	32	39,869
Experiment Station ...	—	—	—	—	—	—
Leave ...	—	—	—	1	1	—
Total A.R.Is. ...		22	7	4	33	

Areas of small-holdings are taken from *Rubber Statistics Handbook*, 1938, and are very nearly the same for all years from 1934 to 1939.

Chinese and Indian owners in Malacca are served by the Chinese and Indian A.R.Is. in Negri Sembilan and North Johore.

(1) Includes Penang

(2) Includes Singapore

(3) Includes Perlis

(4) Includes Labuan

up their permanent stations. The short refresher course which had in previous years been given at Serdang was discontinued this year, as the writer was available to superintend training at the Experiment Station.

At the beginning of the year one Chinese Instructor was transferred to the Botanical Division as a Laboratory Assistant, and in June the engagement of one Malay was terminated. It is regretted that it was not possible to station an additional Instructor in Kedah as was originally intended, since no other suitable candidate was available to fill this unexpected vacancy.

The total number of A.R.Is. in the Service at the end of the year was therefore 33, consisting of 22 Malays, 7 Chinese, and 4 Indians. In the accompanying table showing the distribution of Asiatic Rubber Instructors at 31st December, 1939, the figures (Ref. *Rubber Statistics Handbook*, 1938, p.16) shown in the last column, giving the average area of small-holdings per A.R.I. in acres, do not take account of the fact that many A.R.Is. often work also on small estates over 100 acres in area and several now give advice to estates comprising more than 1,000 acres. This is particularly applicable to most of the Chinese and Indian Rubber Instructors who have been giving advice in connection with extensive areas of new planting or replanting. Consequently in spite of the seven new appointments mentioned above, the effective average area per A.R.I. is still between 50,000 and 60,000 acres.

ASIATIC RUBBER DEMONSTRATORS (A.R.Ds.)

No one who knows Malays and their methods of rubber cultivation and manufacture can gainsay the fact that the major question of improving the quality of sheet produced requires numerous demonstrations at frequent intervals on the proper use of acid and sieve. Improvement being normally slow, constant repetition is necessary. For this purpose Asiatic Rubber Demonstrators were originally appointed and in this connection they have proved to be a marked success, particularly in backward districts. Demonstrations on mouldy-rot control using approved fungicides, in place of tar and other deleterious substances which are often used by small-holders, are now also regularly carried out.

In addition to these duties some have now extended their activities to the construction of smoke-houses, notably in Kelantan, where the scheme was originated by an A.R.I. and where a reasonable premium is paid for smoked sheet. Others have been taught bud-grafting procedure by their A.R.Is. and are now giving occasional demonstrations to those small-holders who

are carrying out new planting or replanting, many of whom imagine that trees can be bud-grafted successfully only with the extensive aid of chemicals.

The distribution of eleven A.R.Ds. at 31st December was as follows:—

State or Settlement	District	Date Appointed	Remarks
Kelantan	Kota Bharu	January, 1938	The first appointment
"	Pasir Pateh	July, 1938	
"	Pasir Mas	May, 1939	
Pahang	Raub	November, 1938	Discharged in November, 1939
"	Temerloh	September, 1939	
"	Pekan	April, 1939	
Selangor	Ulu Langat	December, 1938	Attached to the A.R.I. at Kg. Machang, Kelantan
Brunei	"	March, 1939	
Trengganu	K. Trengganu	June, 1939	
"	Besut	July, 1939	
Province Wellesley	Butterworth	February, 1939	
Kedah	Kulim	March, 1939	

The A.R.D. stationed at Jerteh in North Trengganu works under the direction of the A.R.I. Kampong Machang in Ulu Kelantan. This procedure was satisfactory in dry weather but during the wet monsoon weather proper supervision proved difficult. Following the appointment of a second permanent A.R.I. for Trengganu it is hoped that a more satisfactory arrangement will be possible.

As the scope and effectiveness of the A.R.I. under whom the A.R.D. works is thereby very appreciably increased at comparatively small cost, provision has been made for the employment of 20 A.R.Ds. in 1940. In addition to this increase in scope, an A.R.I. who has an A.R.D. to relieve him of most routine demonstration work can devote more time to the now extremely important subjects of replanting and new planting. In addition the A.R.D. may be trained to help with this latter work by demonstrating physical soil-erosion control measures. For this reason, although all the A.R.Ds. appointed to date have been Malays, it is probable that a few at least of the new appointments will be Chinese and Indians if suitable men can be obtained in those districts where they are most urgently required.

A.R.I. AT THE EXPERIMENT STATION

Since April 1937 there has always been an A.R.I. in residence at the Experiment Station to undergo a thorough "refresher" course and help with sundry small-holding work for which no other A.R.I. can easily be spared. In addition he also assists with Asiatic visitors to the Experiment Station and helps with the new Conductors' Courses.

This policy has been continued throughout 1939 and the experiment has been a definite success, the A.R.I.s. chosen for this special training having obviously benefitted thereby and their efficiency as advisers to small-holders has been increased.

The Malay Instructor who was in residence at the end of 1938 returned to Kelantan in March 1939 and was replaced by a Chinese Instructor from Kajang, Selangor, who remained until August and assisted with the training of the new A.R.I.s. appointed at the beginning of May. A further Chinese Instructor from Perak arrived to take over the duties of the resident Instructor in July and remained until December when he was transferred to Province Wellesley and replaced by an Indian Instructor. The latter was in residence at the end of the year.

ADVISORY POLICY

The function of the Small-holders' Advisory Service is to give advice to small-holders on all technical aspects of rubber cultivation and production. In the past, in order to obtain the confidence of the small-holders, the general policy has concentrated on advice which was both easy and cheap to carry out and which, in addition, showed immediate obvious returns. It was, therefore, concentrated on the preparation and manufacture of an improved product by the introduction of sieves, formic acid, and small cabinet smoke-houses, to replace half-coconut shells with padi straw or lalang, and alum or other inferior coagulants which were both expensive to use and produced poor quality rubber.

The confidence of many small-holders having thus been obtained, a few are prepared to follow advice which is more expensive to carry out and from which no obvious results are immediately forthcoming. Consequently the policy is gradually expanding to include replanting, particularly in those small-holdings in which, owing to excessive tapping and mouldy-rot damage in the past, present bark conditions are poor or where, in a few exceptional cases, the trees are untappable even by a small-holder.

The Small-holders' Advisory Service, in addition to the help which it gives to small-holders, also assists Asiatic owners of larger holdings (i.e. small estates of over 100 acres) particularly

those who are unable to speak English. It is in these areas that the most obvious results have been obtained during the past year, particularly in Negri Sembilan, Malacca and North Johore, where more than 10,000 acres of new planting and replanting by these small estate owners have been undertaken with the help of the Indian and Chinese Rubber Instructors stationed there.

Owing to the new Regulations governing new planting and replanting in 1939, this expansion was more noticeable than in 1938, and with similar conditions governing replanting in 1940, this will probably be still more marked.

PROPAGANDA AND MARKETING COMMITTEE

The Institute continued to be represented on the above Committee at meetings of which Officers of the Department of Agriculture, the Co-operative Societies Department, and the Veterinary Department, are also represented. At these meetings the various activities of small-holders and problems immediately affecting them can be discussed in proper relation to each other.

Preparation and Marketing of Rubber

The teaching of the correct method of sheet preparation was continued during 1939, but owing to the shortage of proper coagulants towards the end of the year, propaganda in this direction became increasingly difficult.

It is regrettable that, from samples of coagulants received at the Institute for analysis from A.R.Is. throughout the country, considerable profiteering at the expense of small-holders appears to have occurred. It is hoped, however, that in view of suggestions recently put forward to the competent authority, the position regarding the sale of these inferior brands of coagulants will be regularised.

Although in normal times sulphuric acid must be regarded as an undesirable coagulant for small-holders, owing to its bad effect on the properties of the rubber produced, notably in connection with vulcanisation, and to the possible wasting effect on sheet mangles, the objections to its use are not sufficiently serious to justify its exclusion when supplies of formic or acetic acid are inadequate. Many samples of coagulants offered for sale were analysed and found to consist mainly of aqueous solutions of sulphuric acid. Since such solutions are odourless, in some instances small quantities of acid-smelling substances were added, presumably to give the liquid a smell resembling that of formic or acetic acid. Such solutions were sometimes advertised and sold as "formic" acid, the manufacturers paying high prices for

empty formic acid demijohn jars. In other cases they were being offered for sale under proprietary names, the price charged being generally some 200 to 300 per cent above their real value in relation to the current market price for sulphuric acid.

The position was alleviated to a certain extent by the distribution of a limited amount of good formic acid by the officers of the Department of Agriculture and other officials, each small-holder obtaining sufficient acid for overnight coagulation of his quota. A number of small-holders in the south are now selling latex in considerable quantity to the agents of a Singapore Company which provides ammonia and drums free.

The improvement in connection with sheet preparation in Kelantan and Trengganu described in the Annual Report for 1938 has continued throughout 1939 and instead of producing slab rubber as in the past, many small-holders in these States now produce much smoked sheet graded as "Chinese Prime." Two remilling factories, which formerly made crepe from this slab rubber, now depend almost entirely on scrap rubber for their continued existence.

However, it is still unfortunately true that in most other localities small-holders continue to be discouraged from the production of good smoked sheet on account of the low premium, if any, offered by local kampong dealers for an improved product. It is therefore apparent that better methods of marketing are urgently required. The question is a very difficult one. The kampong Chinese rubber-dealers have monopolised this business and the question is not eased by the fact that many small-holders are heavily indebted to these dealers who can therefore force the small-holder to accept his price.

The problem has in the past been tackled by seeking the assistance and co-operation of these small dealers, but it is now apparent that real progress can only be attained if this is tackled from the top by obtaining the co-operation of the large dealers or exporters. In this connection it is of interest to note that the Marketing Officer of the Co-operative Societies Department arranged 45 joint sales of small-holders' rubber to exporters in Klang and Kuala Lumpur, a total of 1,019 piculs being sold at an average nett profit of approximately \$1 per picul. In some of these lots thus sold, as much as 90 per cent of the rubber was graded as "Chinese Prime" by the purchasers, thus again confirming the fact that small-holders can produce good rubber under favourable marketing conditions.

The average Malay small-holder, like most agriculturists, is an individualist. He is extremely conservative in his outlook and the profit motive generally makes little appeal to him. There is

often in addition a certain amount of mutual distrust among them which is difficult to overcome. Such a mentality amongst small-holders is extremely favourable to any middleman such as a kam-pong rubber-dealer and adds considerably to the difficulty of marketing.

The pernicious habit of pledging coupons before they have been issued is becoming more prevalent, the price obtained varying from \$3 to \$10 per picul below the market value on the day of issue. In some instances coupons have been pledged on these terms for as long as two years in advance and are commonly known as "macham pension."

Tapping

With the rapid increase in price for uncoupons rubber which followed the outbreak of war, the number of holdings in tapping at the end of the year was much greater than during the first two quarters, and would probably have been still greater had sufficient coagulant been available at a reasonable price.

In general the most common systems of tapping continued to approximate to third and half cuts tapped daily. The cuts are usually irregularly placed and often run in the wrong direction from high right to low left. On most holdings bad wounding is of general occurrence particularly on the older holdings in which renewed bark is now being tapped. This is often unavoidable since this bark is usually extremely hard and uneven due to bad wounding in the past. Many panels would, on estate standards, probably be considered untappable. On the younger Chinese or Javanese-owned holdings, however, tapping continued to reach a very high standard, particularly where this work was carried out by the owner and his family.

Many Malay absentee-owned holdings continued to be rented to Chinese. Towards the end of the year, some owners permitted the work to be carried out by three or four Tamil labourers who had previously worked on estates. In this case the labourers combined and approached the owner to enquire as to the crop he would expect from his holding if they tapped and carried out the other necessary work free for him. The amount of rubber expected being normally quite small, (the owner receiving the coupons), the coolies immediately commenced to "slaughter" tap the trees. In all such cases results have proved disastrous and by the time the owner, who seldom if ever visits his holding under these conditions, appreciates the position, there is little or no bark left and the "tappers" have moved on elsewhere.

Propaganda on the improvement of tapping standards was, however, continued but without any marked success since the

average small-holder still cares little for the rate at which his bark is consumed, and appears to be quite unmoved by repeated warnings as to what may happen in the near future if he continues to tap as wastefully as at present.

Treatment of Land and Soil

Physical methods of soil conservation have, in the past, been carried out in very few, mainly Chinese and Chettiar-owned, holdings in which clean weeding was generally practised. In many of the areas alienated for new planting under the new Regulations during the year, however, much work of this nature has been carried out. This is particularly true in Johore in which State the construction of bunds or terraces together with the planting of leguminous creeping covers is enforced on all undulating or hilly land newly alienated of rubber planting, except on areas of less than 10 acres, which are exempted.

In several small Malay replantings the construction of contour terraces has been successfully carried out, with help from an A.R.I., by means of a wooden hurdle and spirit level. This apparatus can be made or purchased cheaply and is sufficiently accurate for small areas. It has also been used with excellent results by Chinese and Indian owners on areas of more than 100 acres by dividing the area into small blocks and treating each separately.

Propaganda on the establishment and control of indigenous and other covers has been continued throughout the year. Many Chinese owners who formerly practised clean weeding are now endeavouring to establish natural covers, with good results in some districts. A few, following the construction of bunds or silt pits in their old rubber holdings, have sown creeping leguminous cover-crop seeds, with artificial manures. In many Malay holdings flourishing natural covers continued to exist but on account of the fact that these are often allowed to grow unchecked close to the rubber trees, severe attacks of mouldy rot have followed on account of reduced ventilation. A few owners have now, however, cleared strips through the cover along the tree rows and slash the remainder periodically. Unfortunately these have occasionally been weakened by frequent slashing to ground level and sheet lalang has resulted. This has occurred in most instances in those holdings in which the trees are irregularly planted.

An increased interest in manuring was shown by small-holders during the past year. Complete mixtures of inorganic manures being available in small quantities, several of the small-holders undertaking replanting are now using this for their young rubber trees and are, in addition, purchasing rock phosphate for the

creeping leguminous covers which many have also established. As in the past, however, the greatest interest in manuring has been shown by Chinese and Chettiar owners, many of whom have purchased large quantities of manures for use both in the field and in budwood multiplication nurseries. In one State, manures were purchased by the Department of Agriculture for resale at cost price to small-holders in the quantity they desired, with good results.

Pests and Diseases

The most serious disease affecting the rubber trees in small-holdings continued to be mouldy rot, which caused much damage throughout the country, although, owing to the drier weather experienced, attacks were not so virulent as in previous years. In spite of the fact that the Department of Agriculture has continued the policy of selling approved fungicides for the control of this disease, tar and other unsuitable substitutes continue to be extensively used.

It is noticeable that, in districts such as the coastal plain in Kelantan and Trengganu where padi is extensively cultivated, the disease is much less virulent and causes less damage in spite of the damp conditions which prevail during the monsoons. This may be explained by the fact that, on account of padi planting, little tapping is normally carried on in the rainy seasons. During the present year, however, tapping has been much more extensive during this period on account of the high prices offered for rubber, and it is probable that damage from mouldy rot in these districts will be much more extensive.

On account of the replanting now being carried out by small-holders, root diseases have now assumed a greater importance than in previous years. While root diseases are, in general, not such a serious problem in small-holdings as in large estates owing to previous cultivation and growth of "catch-crops" in the early stages, it is essential that any diseased roots should be carefully removed before replanting is completed. Most small-holders cannot normally afford to remove tap roots or the larger lateral roots when felling and these roots remaining in the soil may enable any root disease which is present to spread rapidly with disastrous results to the young replanted trees.

White ants continue to be more generally treated, mainly with "Cymag" and sodium silico-fluoride supplied in some States at cost price by the Department of Agriculture. In a few instances the use of common salt and other equally useless substitutes was occasionally observed.

Replanting and New Planting

Throughout the year a much enhanced interest in connection with the very important subject of replanting has been shown by small-holders and those Asiatic owners of estates who receive advice from the Institute through this Service.

Similarly in connection with new planting. At the time new planting "share certificates" were issued towards the end of 1938, few Malay small-holders appreciated the purpose for which they had been given out or their true exchange value. Later when the new Regulations were more fully understood, many who had previously sold all their certificates proceeded to buy them back at a considerably higher price. Consequently the total amount of new planting now being undertaken by small-holders is very much in excess of the area estimated at the beginning of 1939. For example there have been more than 8,400 applications to plant areas of five acres or less, totalling approximately 16,600 acres.

Unfortunately much of the land alienated for this purpose, in districts where the population is high and cultivation intensive, is poor, being either old, silted padi "sawahs", or other areas where, owing to faulty methods of cultivation in the past, most of the soil has already been washed away. In the first instance it is unlikely that the rubber trees will ever develop satisfactorily even with good drainage, which would be both difficult and expensive to carry out, while continued manuring will probably be necessary for proper future development in the second.

On the other hand several of those who purchased virgin land had not completed the planting up of these areas by the end of the year owing to the fact that the jungle could not be felled until the land had first been surveyed. Much of this virgin land is undulating or very hilly and in some instances the slope is so steep that it does not appear practicable to advise the construction of terraces to minimise soil erosion, owing to the excessive amount of excavation in the solid which would be required to make them. Wherever possible, however, the importance of anti-erosion measures has been stressed. Unfortunately the average small-holder is unable, for financial reasons, to wait five or six years before receiving some return from his land. As a result the "catch-cropping" of new areas is common.

The greatest threat to the successful replanting of small-holdings is, without doubt, the lack of sufficient plant food in the soil to produce a second stand of mature trees, together with the lack of sufficient capital to alleviate this artificially by manuring. Although average soil conditions in small-holdings are probably more favourable from this point of view than those on most of the larger estates, some means of improving these

conditions in establishing a second rotation are undoubtedly necessary in most holdings. If, however, the small-holder would establish a permanent ground cover to protect his soil, from the commencement of the first rotation, this threat would, to a very large extent, be eliminated when it became necessary to replant.

The practice of "catch-cropping" is unfortunately not confined to these newly-alienated areas, but also occurs during the replanting of Malay and Chinese holdings. The former have employed Chinese labour to carry out felling and root-disease work and in part return they have given permission to grow food crops for at least one year.

While it is true that the Asiatic planter, rather than the small-holder, has taken the greatest advantage of the new planting and replanting concessions permitted by the new Regulations in 1939, a certain amount of replanting was also carried out by Malays during the year. To date some 550 applications have been received and approved by the Controller of Rubber, but much of the work completed has been far from satisfactory. In these areas the planting material used has generally been either stumped seedlings or ungerminated seeds collected from neighbouring holdings, planted one, or occasionally two, per point. On account of this paucity of planting material, subsequent damage by rats, and normal failures, development since planting has been very irregular and often poor. In addition proper methods of upkeep such as regular weedings rounds have not always been carried out.

The long periods of intense drought which occurred during the year may also be partly responsible for this poor development, but one of the principal troubles of the "small" small-holder is undoubtedly a financial one since many complain that they cannot afford either the time to carry out the necessary work themselves or pay men to do it for them. It is perhaps unfortunate that such people cannot obtain a loan, in the form of labour, from Government for the purpose of carrying out this necessary work. Much might be carried out satisfactorily by gangs of unemployed coolies.

From figures given in the *Rubber Statistics Handbook, Malaya*, 1939 (page 15), it is apparent that some 919,124 acres of small-holding rubber excluding Perlis, Trengganu, and Brunei, for which no figures are available, were planted on or before 1922. It is reasonably certain that, although the economic life of the rubber tree under average small-holding conditions cannot be definitely ascertained, the greater part of this very extensive area will require to be replanted within the next 10 to 15 years, since by that time

the minimum age will range from 27 to 32 years. It is evident, therefore, that future replanting will require to be carried out on a more extensive scale than at present.

The following summary of applications for new planting and replanting is taken from information received through the Controller of Rubber:—

*Summary of Applications for New Planting and Replanting
up to and including 30th November, 1939.*

State or Settlement	Replanting			* New Planting			Remarks
	Area in Acres	Total Applications	Malay only	Area in Acres	Total Applications	Malay only	
1. In Small-holdings							Replanting totals in U.M.S. are for Kedah and Johore only. Includes Brunei.
U.M.S.	820	148	25	5,051	3,230	162	
S.S.	683	99	54	588	470	121	
Pahang	563	98	62	2,093	1,590	690	
Perak	2,734	663	214	5,230	2,100	1,524	
N.S.	925	141	54	2,837	650	363	
Selangor	2,509	410	146	850	380	173	
Total	8,234	1,559	555	16,649	8,420	3,033	Total applications for new planting; does not include those in Johore.
2. In Medium-holdings							
U.M.S.	—	—	—	—	—	—	
S.S.	1,150	27	—	—	—	—	
Pahang	45	5	—	—	—	—	
Perak	1,236	37	2	—	—	—	New planting combined with large holdings below; no separate information available.
N.S.	1,009	42	1	—	—	—	
Selangor	1,089	35	1	—	—	—	
Total	4,529	146	4	—	—	—	
3. In Large-holdings (Asiatic-owned)							For Kedah up to and including December 1939.
U.M.S.	—	—	—	1,439	22	—	
S.S.	2,273	34	—	1,382	28	—	
Pahang	271	19	—	10,305	49	—	
Perak	873	38	—	2,105	46	1	Only the areas which will probably be advised by the S.H.A.S. are given.
N.S.	2,257	33	—	3,460	42	1	
Selangor	1,413	29	—	333	23	1	
Total	7,087	153	—	19,024	210	3	
Grand Total	19,850	1,858	559	35,673	8,630	3,036	

* The new planting areas in small-holdings are for approved applications of 5 acres or less only and exclude Kedah for which no figures are available.

High-yielding Planting Material for Small-holders

Any extension of the total area planted with selected high-yielding material would, as stated in the report for 1938, place Malaya in a stronger position *vis à vis* other rubber-producing countries apart from the advantages accruing to the small-holder himself by an increase in the yield of latex and in the number of "coupons" received.

The first active steps towards providing small-holders with improved planting materials were taken in 1930, four years before the Small-holders Advisory Service was started, when small demonstration plots of budgrafted rubber were established on several Agricultural Stations of the Department of Agriculture, throughout the country. Additional attempts to increase the interest of small-holders in the use of improved material were made by means of bud-grafting demonstrations at local Agricultural Shows and elsewhere. Courses in budgrafting had also been given annually to the students at the School of Agriculture, Malaya, at Serdang, since the above date.

As a result of this propaganda, some 80 acres in 10 holdings were budgrafted by 1937, but on account of the unfavourable economic conditions during this period, and owing to the fact that new planting was prohibited from 1934 by the Restriction Regulations (and replanting permitted only on a scale uneconomic to many small-holders), comparatively little interest was aroused.

Towards the end of 1938 and during 1939, however, small-holders and the Asiatic owners of small estates have begun to realise the advantages of replanting under the terms of the new Rubber Regulation Agreement. This is clearly indicated in the preceding summary of approved applications to replant.

In December 1938 and January 1939, approximately 600 stumps budded with clones Tj.1 and 16, Avros 49, and B.D.5, from the R.R.I. Experiment Station, were established in 14 Agricultural Stations of the Department of Agriculture, to provide nucleus budwood for multiplication on seedlings planted at about the same time in these Stations. The total area of these multiplication nurseries is approximately 13 acres, and since this is not sufficient to provide budwood for the entire area now being planted by small-holders, it is likely that these will be extended to a total of 53 acres. For the purpose of providing part of the nucleus budwood for these extensions a further supply of some 2,500 Tj.1 and 16 stumps was despatched in November. A limited amount of budwood was also distributed.

Unfortunately distribution of some of the most valuable clones is restricted owing to the fact they are owned by private Companies who will sell only on the completion of a legal agreement

that material will not be multiplied for re-sale. As a result these clones are not, in general, available to small-holders. At first sight it might appear that unrestricted multiplication by small-holders would cause a loss to the proprietors of these clones, but it is very unlikely that this would, in actual fact, be so. Most small-holders, and the smaller Asiatic planters, when purchasing budwood demand an official receipt, since they do not yet fully appreciate the fact that the various clones can be recognised in the field by their vegetative characteristics. For this reason it is probable that there would be little multiplication of such clones for re-sale amongst small-holders themselves.

It is highly desirable that they should, however, have the use of these proprietary clones since some are better than most of the non-proprietary clones which they will otherwise require to use.

The Department of Agriculture and the Rubber Research Institute have kept in close touch regarding this highly important subject and the proprietors of these clones have now been approached in an endeavour to obtain the use of three of these "restricted" clones for Malayan small-holders. It is hoped that the present position will be readjusted satisfactory early in 1940.

Shows

As in 1938 exhibits of interest to small-holders in connection with the cultivation, propagation, and preparation of rubber, were given at various Mukim or District Agricultural Shows, the exhibits being obtained locally and arranged by the A.R.Is. themselves. Suitable descriptive labels in four languages were once again forwarded to each A.R.I. in attendance at a Show. Lectures and demonstrations were occasionally given, those on budgrafting proving to be of most interest.

The Malayan Agri-Horticultural Association Show was held from the 5th to the 7th August and, as in previous years, the Institute assumed responsibility for judging the entries in the Malayan Small-Holders' Rubber Competition. The arrangement of the entries at the Show, however, was this year carried out by the Show authorities themselves. There were some 130 entries, confined to sheet produced and smoked on holdings of 25 acres or less. Although the general quality of the rubber was not so good as in 1938, the prize-winning entries reached the usual high standard. Eight equal prizes were awarded, five going to Pahang, and one each to Brunei, Selangor, and Negri Sembilan. It is of interest to note that this is the first occasion on which entries from Brunei have been received.

The Institute was open to the public during the period of this Show and many small-holders came. No display was given on this

occasion at the Exhibition proper, but by the courtesy of the authorities, hand-bills were distributed there inviting the public to visit the Institute where an exhibit for small-holders showing the various stages in budgrafting was arranged in the front porch. Demonstrations by two budders from the Experiment Station were also given periodically on spare seedlings available for this purpose. The demonstration small-holding (Block D) opposite the Institute was also open for inspection. All three proved to be of considerable interest to visiting small-holders.

Rural Lecture Caravan

As in previous years a caravan, jointly operated by the Department of Agriculture, the Co-operative Societies Department, and the Rubber Research Institute, toured the rural districts in the F.M.S. and S.S. A.R.Is. attended the Caravan when it was touring in their respective districts and gave lectures and demonstrations. They also provided commentaries to the lantern slides dealing with rubber cultivation and preparation. A new set of slides covering normal budgrafting procedure was prepared from the photographs appearing in *Planting Manual* No. 8 and issued for use with the Caravan.

Experimental Work—Ampang

The three small blocks cut out for replanting in 1937 have continued, with one exception, to show excellent progress, while the fourth small area which was replanted in November, 1938, also developed well in spite of the abnormal dry weather and was budgrafted with Pilmoor B.84 in December, 1939.

Since it is intended to replant small blocks almost every year so as to have a series of demonstration areas covering all stages of development, one further area of approximately one acre was cut out this year. Following a tree-to-tree inspection for root disease, the old rubber trees were felled at about three feet above ground level. The stumps remaining did not, however, continue in tapping as in 1938, since the amount of latex obtained on that occasion was very small and did not pay for the cost of tapping. Contour terraces and platforms were laid out where necessary by means of a wooden hurdle and spirit level.

These small areas continue to serve a useful purpose as demonstration and experimental areas for visiting small-holders and Asiatic planters, many of whom are still sceptical as to whether old rubber areas can be successfully replanted. A photographic record is being kept.

In addition a small nursery has been laid out in Block D opposite the Institute and planted with germinated seed. In addition to being useful for demonstration purposes, this will later also be a valuable source of budded stumps.

Conference of Asiatic Rubber Instructors

A very successful Conference of A.R.Is. was held in the Institute from the 19th to the 22nd September. All A.R.Is. including those stationed on the East Coast and in Brunei attended, the writer meeting the latter of the first time. This was the third Conference held since the inauguration of the Small-holders' Advisory Service and was without doubt the largest and most successful. Brief lectures were given by one officer from each Division and, in addition, the Marketing Officer of the Co-operative Societies Department very kindly consented to give an address regarding the co-operative marketing of rubber.

Several A.R.Is. also delivered talks regarding various aspects of the work on which they had recently been spending much of their time, each talk being followed by discussion.

Bark Survey on Small-holdings

The field work in connection with the above survey, which is a development with the aid of recent statistical methods of a similar survey carried out by the Department of Agriculture in 1931/32, was begun during the year. Eight A.R.Is. have now completed the bark measurements on the 20 holdings chosen at random for each of them. The remainder will shortly complete the measurements in the holdings selected and it is hoped that the combined results will be published in 1940. Much of the bark measured in many of these holdings, although exceeding the minimum thickness of 5 m.m., is often extremely hard and of poor quality, and would probably be considered as untappable on large estates. Whether or not it is tappable on small-holders' standards is not known since most of these holdings had been out of tapping for a considerable period at the time bark measurements were completed.

R. H. MEIKLE

Small-holders' Advisory Officer

Kuala Lumpur,

6th February, 1940

ANNUAL REPORT

SMALL-HOLDERS' ADVISORY SERVICE

INDEX

	Page
Appointment of Instructors	239, 240
Advisory policy	244
Agricultural shows	254
Ampang demonstration plots	256
 Budwood supplies	 253
Bark survey on small-holdings	256
 Conference of A.R.Is.	 256
Coagulants, shortage and alternatives	245
Coupons sold before issue	247
Contour terraces	248
Cover plants	248
Catch-crops	250
 Demonstrators (A.R.Ds.), work	 242
" " distribution	243
Diseases and pests	249
Demonstration plots at Ampang	255
 Experiment Station refresher course	 244
 Instructors (A.R.Is.) appointments	 239, 240
" " distribution	241
" " refresher course	241
 Marketing of rubber	 246
Mouldy Rot	248, 249
Manuring	248
M.A.H.A. Show	254
 New planting	 250, 252
 Propaganda and Marketing Committee	 245
Preparation of good quality rubber	246
Planting material	251, 253
 Root diseases	 249
Replanting	250, 252
Rural Lecture Caravan	255
 Soil conservation	 248
 Tours of inspection by officers of the Institute	 239
Tapping practice	247
 White ants	 249

ANNUAL REPORT *

LONDON ADVISORY COMMITTEE FOR RUBBER RESEARCH (CEYLON AND MALAYA)

The Committee and Technical Sub-Committee held three meetings during the year. There was also one meeting of the Sub-Committee on Standardisation of Raw Rubber appointed in 1937.

The Committee regret to report that Mr. Ian D. Paterson and Mr. F. S. Ashby, B.Sc., both of whom rendered very valuable service to the Technical Sub-Committee in recent years were unable to retain their membership.

Mr. Paterson was transferred for duty with the Goodyear Tyre & Rubber Co., in the United States of America and Mr. G. G. Balazs, who has taken his place in the Company's laboratories at Wolverhampton is continuing the very useful work started by Mr. Paterson in keeping the activities of the Committee in close touch with the requirements of American manufacturers.

Mr. Ashby resigned on retirement from the post of Director of the Imperial Mycological Institute, and was succeeded by Dr. S. P. Wiltshire, who is now assisting the Committee on mycological problems.

Meetings of the Committee and Sub-Committee were attended by Mr. H. J. Page, Director of the Rubber Research Institute, Malaya and members of the scientific staff, viz.:—Messrs. C. G. Akhurst, C. E. T. Mann and R. P. N. Napper.

Mr. Page was good enough to place a large amount of his time while on leave in the United Kingdom at the disposal of the Committee and the staff for a detailed examination of a variety of matters relating to the work in London and the East. Largely as a result of his efforts a detailed scheme for co-operation between the British Rubber Producers' Research Association, the Committee and the rubber research organisations in Ceylon and Malaya was agreed with the Association. Arrangements were made subsequently for members of the scientific staff of the Committee to attend the monthly staff conferences held by the Director of the British Rubber Producers Research Association at Welwyn.

Following the appointment of Mr. W. S. Davey, Senior Assistant on the staff of the Committee as head of the Chemical Division, Rubber Research Institute, Malaya, Mr. Page reviewed the programme of work in London at the request of the Committee. He reported that he was satisfied that there was still ample scope

* An index follows page 277.

for the employment of a graduate staff of three as hitherto, and for an assistant staff at least as large as at present. On his recommendation, the vacancy arising from Mr. Davey's departure was filled by Mr. W. G. Wren, whose work on roadway problems ceased on 31st May 1939 owing to the decision of the British Rubber Producers Research Association not to continue the grant previously made for work on this subject.

The Board of the British Rubber Producers Research Association also decided to discontinue, as from 1st April, 1939, the grant made in recent years for co-operative research with the Limmer & Trinidad Lake Asphalt Co., on rubber bitumen mixtures for roadways and, as a result, the services of Mr. T. A. Sharpley had to be terminated by the Committee; he was, however, given further employment by the British Rubber Producers Research Association.

Arrangements were made by the Association for work on the subject to be undertaken by the Road Research Laboratories at Harmondsworth and for the experience gained by the staff of the Committee and of the Limmer & Trinidad Lake Asphalt Co., to be utilised in drawing up programmes for further investigations and in reviewing the results obtained.

CO-OPERATION WITH OTHER ORGANISATIONS

Close co-operation was maintained throughout the year with the Research Association of British Rubber Manufacturers whose help in connection with the work of the Standardisation Sub-Committee is of particular value.

Mr. Martin continued to serve on the Committees of the Research Association of British Rubber Manufacturers and of the British Standards Institution and on the Council of the Institution of the Rubber Industry.

Facilities were provided on a number of occasions for members of the staff of the British Rubber Producers Research Association working in other laboratories in South Kensington to use the heavy rubber machinery in the Committee's workshops.

FINANCE

Contributions of £2,625 and £875, were received from the Rubber Research Institute and the Rubber Research Scheme respectively towards the cost of the work of the Committee during the year 1939. The expenditure incurred amounted to £3,605.19.1, and after allowing for reserve for plant and for liabilities outstanding, there was an unexpended balance of £1,200 at 31st December 1939.

ACTION ARISING OUT OF THE WAR

At their first meeting following the outbreak of war the Technical Sub-Committee reviewed the programme of work and it was unanimously agreed that the existing programme should be continued so far as the staff available permits. Minor modifications, however, have been made to meet special applications of rubber to war needs.

The Committee approved a scheme for co-operation with the Research Association of British Rubber Manufacturers in dealing with problems of national importance and referred to the Association by Government Departments and the rubber manufacturing industries. Approval was given to Mr. Martin assisting the Ministry of Economic Warfare in connection with various enquiries on rubber.

The Committee have agreed that any member of the permanent staff called up for service with the Armed Forces of the Crown, whose civil pay exceeded his service emoluments should be eligible to receive the balance of his civil pay to bring up his total emoluments, civil and service, to the level of his civil pay.

Arrangements were made for suitable laboratory and office accommodation to be available for the Committee in connection with the evacuation scheme for the Imperial Institute, should it be necessary to leave London.

STANDARDISATION OF RAW RUBBER

As indicated in the report for 1938, the work on this subject has been proceeding in two main directions—(1) the preparation of a uniform rubber as measured by physical tests and (2) the possibility of devising a scheme as suggested by Dr. H. A. Tempany for the identification by an officially recognised mark of rubber from estates adopting an agreed standard of cleanliness in order to meet the complaints from manufacturers that 10% of first grade rubber contains sand in such quantity as to make it unsuitable for use in the manufacture of tubes and other thin articles.

During the year the preliminary work on the preparation of a detailed specification of the procedure to be adopted and the apparatus to be employed in testing rubber for this purpose was completed and copies circulated for comment to (1) the rubber research organisations in Ceylon and Malaya; (2) the International Rubber Research Committee (for the views of corresponding organisations in foreign countries) and (3) to representatives of manufacturers in the U.S.A. and in this country.

In connection with this investigation the Rubber Research Institute, Malaya, and the Rubber Research Scheme, Ceylon, are undertaking the examination of a large number of samples of

estate rubber in order to obtain adequate data to enable suitable standards and tolerances to be calculated.

Arising out of the enquiry by the Standardisation Sub-Committee concerning the nature of the mechanical impurities in raw rubber as received at the factory, investigations carried out with the help of Dr. Twiss showed that first grade sheet rubber may contain many particles of sand which are too small to be separated by straining the latex. If the latex is allowed to settle after dilution, however, and then all except the lower layer run off, the rubber obtained is found to be free from sand, but it still contains a small quantity of light impurities such as pieces of bark and seeds, which, being soft, are likely to be dispersed during manufacturing operations.

In view of the fact that the results showed that appropriate action on estates should help in reducing the difficulty experienced by manufacturers owing to the presence of dirt in rubber, the Committee decided to ask the Rubber Growers' Association, the Rubber Research Institute and the Rubber Research Scheme, for their views as to whether a scheme for a recognised mark for clean rubber on the lines suggested by Dr. Tempany would be practicable, and if so, whether it would be of advantage to the rubber growing industry.

INVESTIGATIONS

The object of the investigations in London is to improve the quality of latex and rubber in close collaboration with the rubber research organisations in Ceylon and Malaya. In recent years, owing to improved facilities and equipment becoming available in the East, changes have taken place in the scope of the work undertaken in London, and the investigations carried out under the auspices of the Committee are now concerned mainly with the development of methods of testing and confirming, under European conditions of manufacture, the results obtained in the East on tests with the raw material.

After many years experience and research, the testing of raw rubber has been proceeding for some time on generally agreed lines, but there is an increasing feeling on the part of some technologists that physical properties which have been ignored hitherto are probably of equal, or even greater importance than those already studied. Although there is undoubtedly scope for a fundamental investigation of the testing of dry rubber, it has been considered desirable to concentrate on the technique of the testing of latex. With its much shorter history as a commercial product the factors determining its suitability for manufacture are still ill-defined, and testing methods which meet with general

approval are not available. The manufacture of articles from preserved latex nearly always involves compounding and coagulation, after which the problems of utilisation are akin to those associated with dry rubber. The behaviour of latex in the presence of compounding ingredients or coagulants depends upon three inherent factors, viz., (1) the nature and distribution of the rubber hydrocarbon, (2) the nature and concentration of substances constituting the boundary between rubber and serum and (3) the nature and concentration of the serum solids.

A detailed systematic study is therefore being made to determine the importance of each.

It will be some considerable time before all the aspects of these investigations can be completed, but already it has been ascertained that (1) the relative amounts of soap and protein at the boundary between rubber particle and serum and (2) the nature and concentration of the serum substances are of importance. Further investigations are proposed to measure these factors by simple tests.

In the work on dry rubber particular attention has been paid to varying methods of preparation with the object of obtaining types of rubber having special properties so as to strengthen the position of the plantation product in meeting increasing competition from synthetic materials. In this connection close co-operation has been maintained with the chemical staffs in Ceylon and Malaya in their work on the preparation of soft rubber and rubber with low water absorption properties. Tests in the Committee's laboratories have confirmed the widely expressed view that some synthetics prepared in Germany are definitely superior to some types of plantation rubber as far as abrasion is concerned. There is, however, no method generally accepted by rubber technologists for testing abrasion; the method referred to in the Report for 1938 was found to be less reliable than was expected but the causes of this have been determined and steps are being taken to improve the test. It is of interest, however, that one sample of rubber prepared by a special method appeared to be superior to others prepared by ordinary estate methods, but no definite conclusions can be drawn until the method of test has been improved.

A list of the reports furnished on these investigations and on others initiated in the Committee's laboratories is given below. Further information as to the investigations completed and in progress during 1939 will be found in the technical appendix to this report.

REPORTS ON INVESTIGATIONS FORWARDED TO CEYLON AND MALAYA DURING 1939

LATEX

Testing

Determination of the dry rubber content of latex:—

- (a) Comparison of results given by different methods.
- (b) Influence of rate of addition of coagulant.
- (c) Comparison of results obtained in different laboratories.

Stability tests for latex.

Stability of compound latex.

Colloidal Properties

Distribution of nitrogen by creaming.

Distribution of nitrogen by centrifuging.

Relation between the creaming power of sodium alginate and the viscosity of its solutions.

Comparison of (N_r) and (N_g) by creaming and centrifuging.

Changes in the distribution of serum substances in latex on keeping and their relation to stability.

Effect of dilution on the distribution of nitrogen in stored latex.

The relation (N_r) and (N_g) of different latices.

The effect of caustic soda on the distribution of nitrogen in latex.

The effect of soaps.

Accuracy of determinations.

Storage

Effect of storage on the properties of latex.

Latex from Ceylon.

Preservation

Preservation of latex with sodium pentachlorophenate.

Dried Latex Films

Effect of conditions of storage and accessory substances on the properties of unvulcanised rubber.

Tensile strength of dried latex films.

Reversible dried latex films.

Mechanical properties of dried latex films.

DRY RUBBER

Abrasion

Development of a resistance to abrasion test for comparing different samples of rubber.

The resistance to abrasion of purified rubber.

The resistance to abrasion of special types of rubber.

Purified rubber

Purified rubber prepared in Java.
 Rubber from latex purified by multiple centrifugal creaming.
 Purified rubber from West Java.

Standardisation of rubber

Results of comparative tests by the Goodyear Rubber Co., and the L.A.C. staff using the tentative specification.
 Scorching test.
 Comparative tests with other laboratories.
 Mechanical impurities in sheet rubber.
 Co-operative tests with the Research Association of British Rubber Manufacturers.

Softened Rubber

Softened rubber from Malaya.

Miscellaneous Samples

Unsmoked sheet from a Malayan Estate.
 Tissue rubber.
 Note on the use of paper linings for rubber packing cases.

PATENTS

In conjunction with the British Rubber Producers' Research Association, steps were taken to obtain English patents in connection with the inventions arising out of the work of the staffs in London and the East. As in previous years, the Rubber Research Institute, Malaya and the Rubber Research Scheme, Ceylon were supplied with copies of specifications in respect of inventions relating to processes for the preparation or utilisation of raw rubber and latex likely to be of interest to them.

Provisional Specifications accepted during 1939

13944/39 Compounding latex
 22153/39 Peptising Agents (communicated by the R.R.I., Malaya)

Provisional Specifications filed during 1939

31244/39 Captax as Peptising Agent (communicated by the R.R.I., Malaya)
 31245/39 Benzoyl Peroxide as Peptising Agent (communicated by the R.R.I., Malaya)

Other Patents in force at 31st December 1939

428100 Rubber and Road Tar Mixtures
 450222 Hemicellulose Creaming Agents
 465226 Organic Liquid Addition to Latex
 415133 Organic Colloidal Addition to latex
 476743 Preparation of Chlorinated Rubber

474651	Concentration of Latex by Creaming
476269	Brominated Rubber
476073	Stabilised Cream
484712	Rubber and Cement Mixtures

Patents abandoned during the year

395774
395775
396880
433303
430935

P. J. BURGESS

Chairman

J. A. NELSON

Secretary

Imperial Institute,

April, 1940

TECHNICAL APPENDIX

TO THE REPORT OF THE

LONDON ADVISORY COMMITTEE

Latex

As explained in the last report (1938) the object of the investigations on latex is to devise tests for quality and for this purpose the rubber globules, the aqueous serum and the boundary surface between globules and serum are, as far as possible, receiving separate attention. This is an ideal which it is difficult to attain in practice because the phases are to a large extent inter-dependent and an alteration in one is usually responsible for alterations in the others. The results of each investigation can generally be analysed, however, in terms of the three phases and this treatment is applied wherever possible.

LANGMUIR TROUGH

An investigation commenced during the year consisted in an attempt to measure differences in samples with regard to the average diameter of the rubber globules and the average mechanical forces between them using for the purpose a Langmuir trough as modified by Adam and others (*The Physics and Chemistry of Surfaces*, 2nd edn. 1938 p. 28). A drop of latex was found to spread rapidly on a clean surface of water, the globules becoming well separated, but remaining in the surface and not penetrating into the bulk of the water. The latex was then spread on water in a trough and the globules pushed together until microscopic observation showed that they touched. On compression there was a tendency for a small proportion of the particles to enter the bulk of the water, but this was avoided by spreading the latex on a solution of sodium alginate. From the area occupied by a given quantity of latex of known dry rubber content, a value was calculated for the average thickness of the rubber film. Since this film appeared to be one particle thick, the value obtained should correspond to the average diameter of the rubber particle as defined by the total volume of the particles divided by the total area of the cross section. A value of 0.8 microns was obtained for a random sample of ammonia-preserved field latex. This value is much higher than that found for two samples by Lucas using ultra-violet light photomicrographs, his average diameter being 0.44 microns (*Ind. Eng. Chem.* **30**, 1938, 146). An examination of a film occupying an area corresponding to an

average thickness of 0.44 microns showed that the latex particles were a long way from the position of closest packing, clear spaces being observed between most of the particles. When four samples of latex were examined (prepared from the same parent latex, but differing in concentration of serum substances and rubber and in particle size) the relative thicknesses of the films corresponded with what would be expected from a knowledge of the methods employed to prepare the samples. The use of the Langmuir trough to determine particle size was disappointing in so far as the position of close packing could not be determined with sufficient accuracy for a comparison of normal latices where differences in average particle size are not likely to be large.

A measurement of the surface pressure developed at different compressions of the latex film showed that the relation between pressure and area could be divided into two portions separated by a region near that corresponding to closest packing. In the first region where the area was large and the pressure relatively small, the pressure was directly proportional to the concentration of serum substances, and an increase in pressure inversely proportional to the decrease in area. It is evident, therefore, that this portion of the curve is mostly due to serum substances. In the second region there was a marked increase in pressure with decrease in area, the surface film was creased and folded, and the pressure developed was undoubtedly partly due to the irregular piling of rubber globules on each other.

The investigation has shown that the Langmuir trough may be useful for obtaining a quantitative estimation of surface-active materials in latex, but is not likely to yield other information concerning quality. Its value cannot be fully determined, however, until more is known about surface active materials in latex and their relation to variation in properties.

The author is indebted to Professors Adam and Rideal for the interest which they have taken in this investigation.

THE SURFACE OF THE RUBBER GLOBULE

In the last report particulars were given of a method of determining the amount of nitrogenous substances associated with the rubber in latex, as compared with that in the aqueous phase, by determining the amount of nitrogen in the serum and subtracting it from the total nitrogen in the latex. Prolonged centrifuging is required to obtain a rubber-free serum, but it has now been found that serum from creamed latex gives the same result as that from centrifuged latex. Accordingly the determination of nitrogen (and probably other substances) associated with the rubber globule presents no special difficulty. An independent check

on the values determined was obtained by the analyses of crepe from different latices after removal of 98% of the serum substances by repeated creaming, the agreement being excellent.

An examination of samples of centrifuged skim and cream from the same parent latex showed that there was more than twice as much nitrogen associated with the rubber in the skim (0.289%) as in the cream (0.133%), the parent latex being intermediate (0.152%) in this respect. Since the nitrogen is not greatly affected by dilution and there is evidence that all except a small proportion (0.02% calculated on the rubber) is on the surface, the results show that the particles in centrifuged skim are on an average only half the diameter of those in centrifuged cream, on the assumption that the concentration of nitrogen per unit of surface is the same for large and small particles.

A study of the effect of heating latex with caustic alkalis showed that the surface nitrogen slowly passes into the aqueous phase, but there is about 0.02% which remains with the rubber. A temperature of 50°C is required to enable the reaction to proceed to substantial completion in less than a week, but at 70°C only one day is required. Caustic potash is not as effective as the same concentration by weight of caustic soda. The purification of latex with caustic alkalis by Pummerer's and similar processes is, of course, well known, but it has not been quantitatively demonstrated before that the alkali causes surface nitrogenous substances to pass into the aqueous phase of the liquid latex.

The effect of caustic alkali is undoubtedly due in part to the decomposition of surface protein. A method of removing nitrogenous material from the surface of the rubber globule without chemical decomposition has been discovered in the course of the investigation. When latex is treated with a soap such as potassium or ammonium oleate all the nitrogen except 0.03% (calculated on the rubber) passes into the aqueous phase, the surface nitrogenous material being replaced by soap. This is apparently due to the more surface-active material replacing the less surface-active material at an interface (Adam *loc. cit.* p. 98).

Since the rubber in ammonia-preserved latex contains about 2% naturally occurring fatty acids (Rhodes, *J.R.R.I.M.* **9** (1938) 134) which are likely to be present as ammonium soaps, fresh field latex should contain more protein at the surface of the rubber globules than the latex used for manufacturing purposes. The exact amount is somewhat difficult to estimate, because small quantities of soap replace more protein per unit of soap than larger quantities. The information obtained, however, suggests that there is sufficient ammonium soap in preserved latex to

replace at least one third of the surface protein in fresh latex. This would account for the different behaviours of the two types of latex with respect to acid coagulants and would also explain why Rhodes finds a highly significant correlation between coagulation by zinc oxide and the amount of fatty acid in preserved latex (*loc. cit.* p. 157). It is concluded that the determination of the fatty acid content of the preserved latex is of importance for controlling the quality of the liquid latex, particularly as in the case of two ammonia-preserved latices it was found that there was a considerable decrease in surface nitrogen over 14 months, an increase in acid value, and a decrease in stability to zinc oxide.

The possibility of preparing purified rubber by treating latex with soap has received attention, but it is found that 4 or 5% of soap (calculated on the rubber) is required to replace all the surface protein and that it is necessary to have a similar proportion in the aqueous phase. The soap cannot be easily removed on a practical scale and the presence of such large quantities confers undesirable properties on the rubber.

From the quantitative decrease in the rubber phase and associated substances when latex is treated with potassium oleate, it is concluded that the soap displaces an unknown substance in addition to protein from the surface of the rubber globule, the amount displaced being directly proportional to the concentration of the soap at the surface. The displacement continues to occur after all the surface nitrogenous substances have been removed and the experiments are being extended to determine whether the unknown material contains phosphorus.

The fact that neither caustic alkali nor soap completely removes the nitrogenous substances associated with the rubber indicates that from 0.02 to 0.04% (calculated on the rubber) is more intimately associated with the rubber than the rest and is probably not on the surface, but distributed throughout the mass. That a small quantity of nitrogen in rubber is difficult to remove is generally known to rubber technologists, but it has not been demonstrated before that there is probably a difference in distribution of this nitrogenous material as well as in its chemical composition.

STABILITY OF LATEX

One of the most important properties of latex from the industrial point of view is its resistance to coagulation during processing. A number of laboratory tests have been devised to enable an estimate of this property to be made but owing to the variety of conditions under which latex is used commercially, no one test has so far been wholly satisfactory. The zinc oxide

stirring test developed a year or two ago in the Committee's laboratories is still found to be of service but the fact that slight modifications in the conditions of the test alter the order in which a series of latices has been ranged for stability shows that it may sometimes give misleading results.

There is a need, therefore, for a systematic study of the fundamental factors controlling the coagulation of preserved latex. Such an investigation is already in hand, but it will be some time before sufficient data have been collected to enable satisfactory means of testing to be suggested. In the meantime, practical tests are being sought which give empirical information concerning coagulation under given conditions.

In preliminary experiments the coagulation of the latex was brought about in two ways, viz. (1) by stirring in the presence of "superfine" silica, (2) by mixing the latex with aluminous cement. There was little agreement between the results of the two tests. Thus latex preserved with sodium pentachlorophenate gave a low stability by the friction test and a high stability with the cement. The cement test was a practical test developed in connection with an investigation on latex-cement mixtures for flooring, but it was decided that coagulation by a less complex system of electrolytes than that provided by aluminous cement was desirable.

In a further series of experiments, the latices examined were prepared by creaming and centrifuging from one parent latex, coagulation being brought about by stirring with finely divided silica or with electrolytes, such as calcium chloride or sodium silicofluoride. The latices were found to arrange themselves in approximately the same order of stability irrespective of the method of test, but coagulation with sodium silicofluoride gave a better end-point than the other methods. It is interesting to observe that with these latices which varied only in particle size and quantity of serum substances present, there was good correlation between the concentration of nitrogen in the serum and the stability. Other experiments showed that there was good correlation between rubber concentration and stability at the same concentration of serum solids. There was no obvious connection between particle size and stability. As the samples were prepared from the same parent latex it is unlikely that they differed appreciably with regard to the concentration of substances at the interface, although of course there were differences in the amount of surface nitrogen calculated in terms of rubber volume or weight. In these circumstances it is not surprising that there was no evidence that surface nitrogenous substances were responsible for differences in stability between the samples.

Taking into account the whole of the experiments on latex referred to in this report and also the publications of other workers,

it is considered that the surface of rubber globules (e.g. relative proportions of soaps and protein) determine the resistance of the latex to coagulation by electrolytes, but the concentration of coagulating ions is partly dependent upon aqueous serum substances, which are, therefore, also of considerable importance in connection with stability. Consequently further material progress requires the development of a method of measuring surface concentration of substances at the rubber-serum interface and a study of the effect of serum substances on the formation of coagulating ions. A method for the determination of the concentration of surface substances in terms of rubber mass has been developed, but information concerning average particle size is required before the results can be expressed in terms of surface area. Coagulation is a synthesis of complicated phenomena, but it is hoped that this analysis of the factors involved will enable tests for quality to be developed of a fundamental as distinct from an empirical character.

KEEPING PROPERTIES

During the past three years observations have been made on the changes which occur when ammonia-preserved field and concentrated latex are kept for some time. Although this examination does not comprise a comprehensive investigation of the changes occurring in latex on keeping, it has yielded information of value in planning a more thorough and systematic study.

Samples of field latex from Malaya preserved with varying quantities of ammonia showed a general small decrease in dry rubber content and alkalinity and a large decrease in stability to the zinc oxide test, over a period of three years. At the end of three years the latices were in a bad condition, being very unstable and containing lumps of coagulum.

Samples of field and creamed latex from Ceylon, which had been stored for two years showed a small decrease in dry rubber content and stability, but no change in alkalinity could be detected. The field latices were originally more stable than the creamed samples, but at the end of two years they had about the same stability. There is evidence that the decrease in stability is partly due to the formation of ammonium soaps which replace the protein at the rubber-serum interface and do not protect the latex against coagulation by zinc oxide as efficiently as proteins. Storage in glass bottles, as compared with tin-plated iron cans, gave no appreciable difference save in colour, the bottle samples having the better colour.

PROPERTIES OF DRIED LATEX FILMS

Particulars were given in the last report of experiments on the mechanical properties and solubility of unvulcanised dried-

latex films and attention was called to the difficulty of using such measurements to determine the quality of rubber in latex, chiefly because the variations were found to be dependent upon serum substances and not on the quality of the rubber hydrocarbon and the properties of the rubber were markedly affected by traces of moisture and by changes which occurred on keeping. This experiment has been in progress for 18 months and has now been brought to a conclusion. The outstanding features of the results are (1) there is a remarkable decrease in the tensile strength of all samples in the relatively short period of 18 months; (2) at the end of this period nearly all the samples are extremely hard in spite of their poor tensile strength; (3) under favourable conditions the proportion of rubber insoluble in solvents may be over 60% and (4) on the whole, increased tensile strength, hardness and insolubility are favoured by dry atmosphere, serum substances, and absence of oxygen, the dry atmosphere being the most important factor.

These conclusions, of course, only apply to dried-latex films from ammonia-preserved latex, although previous experiments have shown that crepe from fresh latex becomes very hard on keeping in a dry atmosphere. The results now obtained indicate more clearly than before that extensive changes may occur in the mechanical and chemical structure of raw rubber on keeping for a few months, although, of course, these changes are likely to lose much of their importance when the rubber is masticated and vulcanised. They may, however, be of importance in the manufacture of vulcanised articles direct from latex and are, in any case, worthy of more detailed study in order to obtain a complete picture of the properties of rubber.

The fact that serum substances have a marked effect on the tensile strength of dried-latex films has led to experiments in which the serum substances were replaced by colloidal proteins such as glue and casein, both of which were found to improve markedly the tensile strength of dried films from purified latex.

That complex proteins should have this effect is at first surprising, particularly as it is generally assumed that compounding ingredients do not reinforce latex, but information has now been obtained which indicates a possible explanation. Experiments have shown, for example, that an acidic gel such as silicic acid markedly improves the strength of latex films from normal ammonia-preserved latex. When the latex is treated with a kationic soap and then with silica gel, the dried film has no coherence. Similarly a basic gel such as aluminium hydroxide only reinforces the latex rubber in the presence of a kationic soap or amphoteretic protective colloids. The results suggest that good strength is dependent upon a chemical bond between the rubber

and non-rubber substances and that this bond hinders the unraveling of the tangled chains of rubber molecules and so leads to increased strength.

Whether the explanation offered is correct or not, the results definitely show that the mechanical properties of dried films are greatly influenced by conditions obtaining at the rubber-serum interface in latex. It follows that further study of the phenomena is of considerable importance in order to be able to compound latex so as to obtain the best technical results. The technique of the investigation is not easy, however, because of the difficulty of avoiding spurious effects due to oxidation and the preparation of satisfactory films free from flaws. In view of the calls on the time of the staff it is proposed therefore to discontinue the investigation for the present.

An interesting development from the above investigation is the observation that normally dried films containing 2% saponin completely redisperse to latex when immersed in water for a few minutes, no stirring being required. These reversible films are transparent, but contain about 1% moisture when kept in the laboratory and in this condition they remain dispersible for many months. They become irreversible if they are dried further or if they are heated to 70°C or over or are immersed in water at this temperature or if they are deformed by light pressure or stretching. Purified latex does not give such good reversible films as whole latex. The evidence suggests that serum and saponin together form round each rubber globule in latex a protective film which when air-dry has greater mechanical strength than usual. The dry rubber film in consequence retains a structure consisting of the original latex particles completely surrounded by the protective colloids present. Heat or mechanical treatment is required to cause the caoutchouc phase to break through the rigid non-caoutchouc phase to form a continuous medium. The idea of preparing reversible rubber for commercial use is fascinating, but the present product is too sensitive to have practical application.

Dry Rubber

The investigations on dry rubber have been chiefly concerned with the preparation of grades with special qualities for which there is a demand by manufacturers. The development of practical methods of preparation is chiefly the concern of technologists in the East, but the development of suitable testing methods and confirmatory tests on quality are conveniently carried out in London where close touch can be easily maintained with the views of manufacturers. The special grades of rubber to which attention has been given are (1) clean and uniform rubber, (2)

rubber with improved resistance to abrasion, (3) soft rubber and (4) rubber with reduced tendency to absorb water from a damp atmosphere.

STANDARD RUBBER

The problem of preparing clean rubber of uniform quality is one which has been frequently discussed in previous reports, but the technical difficulties involved are complicated and some of them do not admit of an immediate solution. There is evidence, however, that such causes of variability as are beyond control remain constant over long periods. It should be possible therefore to obtain a limited measure of standardisation, which although imperfect, would be preferable to many years of research with no immediate prospect of reaching a definite goal. The work is therefore proceeding on carefully considered lines which appear to offer a practical outcome in the shortest time.

Most of the investigations on the preparation of uniform rubber are naturally carried out in the East. The work in London has been devoted chiefly to the revision of a detailed tentative specification of methods to be employed in the testing of standard rubber. This was complete at the end of the year and the specification is ready for circulation with a view to obtaining suggestions and comments from interested organisations. As far as possible the specification conforms with the methods of test recommended by the British Standards Institution and the Crude Rubber Committee of the American Chemical Society. In a few particulars different practices are recommended by these organisations and the question of which practice to adopt is difficult to decide, as differences in European, American and Tropical conditions make a particular practice convenient in one country and not in another. No decision has yet been reached and suggestions from other organisations are being invited.

Experiments are in progress with the Research Association of British Rubber Manufacturers to ensure that the recommended testing methods will give approximately the same results in both laboratories and to discover how differences between laboratories are likely to arise. This investigation will take some time as each step described in the specification is being subjected to test and retest according to the differences in the results obtained.

The preparation of clean rubber received special attention this year because manufacturers have called attention to its urgency and it was demonstrated that the foreign matter complained of is frequently not due to careless handling or packing of the dry rubber. Experiments in conjunction with the Dunlop Rubber Co., have established that this foreign matter is chiefly

sand and that first grade sheet is liable to contain many particles nearly all of which are so small that they would pass through a latex strainer, but which are sufficiently large to cause difficulty in the manufacture of thin-walled rubber articles such as tubes. It was considered that these particles of sand probably entered the latex during collection and transport, and experiments in conjunction with the Rubber Research Scheme, Ceylon, have now shown that crepe, prepared from diluted latex from which sand has been allowed to settle out, is entirely free from siliceous matter on arrival in London. It is evident, therefore, that there is no technical difficulty in preparing clean rubber and the appropriate steps to implement this finding are under consideration.

ABRASION RESISTANCE

Properly compounded and vulcanised rubber has a remarkable resistance to abrasion, but in view of the German claim that some synthetic materials are distinctly better, there is a case for exploring the possibility of preparing an improved grade of plantation rubber with increased resistance to abrasion. Investigations were commenced in 1938, and it was then pointed out (Annual Report, 1938) that the first step was to develop a satisfactory test. Tyre manufacturers have undoubtedly acquired a considerable amount of information concerning testing technique, but much of this information is not generally available outside the firms concerned. There is, however, general agreement that although the tests are sufficiently reliable to be useful in indicating results which may be expected in practice, they sometimes give misleading results; it is important that conclusions should be checked by road trials. It was considered sufficient therefore to devise a test capable of detecting improved types of rubber in the laboratory, in the hope that some of the results would be of sufficient interest and reliability to encourage manufacturers to carry out practical trials.

The chief difficulties in testing rubber for resistance to abrasion are (1) the sample must be mixed with carbon black and other compounding ingredients under rigidly controlled conditions, which are not easy to obtain on small laboratory rolls, and (2) not only must the vulcanised sample be exposed to abrasive friction of the required type but, according to information available, the abrasive particles must not be allowed to cling to the sample. The continuous removal of abraded particles is difficult with the "gummy" type of tread stock in general use.

The problem of the control of mixing conditions on small laboratory rolls has not yet been solved satisfactorily, but mechanical changes in the mixing rolls are being made and should have

the desired effect. Most attention has been given so far to a study of the abrasive part of the test, and particularly to the removal of abraded particles. Brushing the sample during test with a revolving wire or bristle brush is the usual practice for "non-gummy" mixtures, but does not remove the abraded particles in the tread mix employed. The difficulty was overcome by supplying a continuous stream of a special grade of sand between the test specimen and the abrasive surface, but the sand was subsequently replaced by carborundum powder to conform with suggestions from manufacturers. Fairly uniform results were obtained at first, but the accuracy of the test quickly deteriorated owing to wear of the abrasive surface, and the difficulty of keeping carborundum powder out of the bearings of the machine. Other methods were then tried, but none proved wholly successful partly due to the heat generated by friction with the sample under test. The removal of abraded particles is stated to be necessary because their presence reduced the loss on abrasion, and therefore gives a misleading favourable result (Lambourn, *Trans. I.R.I.*, 1928, 4, p. 210) but in the course of the investigation the presence of abraded particles was shown to have the opposite effect. This is difficult to understand, but the fact was established by repeated experiments in which the only variation was the removal or non-removal of the abraded particles during test. The necessity for continuously removing abraded particles is therefore in doubt, and it is proposed to discontinue this complication of the test.

Among other factors studied the temperature of the test specimen was found to have an important effect on the results. This is difficult to control owing to heat generated in moving parts of the apparatus and transmitted to the test sample. Attempts are being made to increase the control by measuring the temperature developed in the sample during test.

Because of the above difficulties progress in the comparison of the abrasion resistance to special rubbers has been difficult. Several samples of rubber from different clones have been found to give results similar to those given by ordinary sheet from seedlings, but a sample of purified rubber has given superior results. Four separate experiments on two different samples of the purified rubber have indicated that it is more resistant to abrasion than control sheet, but it is not clear whether this is due to a difference in the degree of vulcanisation, the purified sample vulcanising more slowly than the control, or whether it is inherent in the rubber. The correlation between abrasion loss and modulus is very high (0.80 for 14 pairs of tests) so that the degree of vulcanisation appears to be a likely explanation.

Two manufacturing organisations have also carried out tests on these samples of purified rubber. One is of the opinion that

the purified rubber is not superior to standard rubber and has confirmed this conclusion by road tests. The other has obtained preliminary results suggesting that the rubber is superior. The problem is being further studied, but until the proposed modifications of the test are complete and found to be satisfactory little progress can be made in distinguishing between different types of rubber.

MISCELLANEOUS TYPES OF RUBBER

Investigations on softened rubber and rubber with low water absorption properties have been confined to the examination of promising samples prepared in the East. Reports have been forwarded for the information of the technical staff concerned.

Application of Latex to Road or Floor Surfacing

This investigation has been proceeding since 1935 and was brought to a close during the year at the end of May. Throughout the period of the investigation mixtures of latex and aluminous cement have received almost continuous attention, chiefly because they were the most promising and the reason for their technical merits was not obvious. The investigation indicated that these mixtures owed their advantages to colloidal hydration products of the cement which formed a rigid and continuous gel structure throughout the mass of the rubber. It was considered, therefore, that other gel-forming materials might give useful products. Of those tried silica gels gave the most promising results, and the short time available for the investigation during the year was therefore devoted to a study of these new mixtures. The silica gel was formed *in situ* in the latex by adding organic silicates which were hydrolised by water to form silica gel. Only a small quantity of the gel was required to give a rigid product suitable for flooring, but before the mixtures could be recommended for commercial exploitation many details required attention, such as correct stabilisation of the latex to obtain the most suitable rate of coagulation, treatment with compounding ingredients to cheapen the product, retarding and accelerating the gelling process so as to ensure a hard product within convenient limits of time. It was not possible to develop a composition suitable for commercial exploitation in the five months available, but laboratory scale trials showed that the new mixes were an improvement over aluminous cement mixtures with regard to colour and the absence of dirt-ingraining, which is an important problem in cement-latex mixtures. Mixtures of silica gel and snow-crete (white Portland cement) were particularly promising.

Although the process was not sufficiently developed for commercial use, laboratory samples and the methods of preparation were shown, at the request of the Director of the British Rubber Producers Research Association, to three firms interested in latex-cement flooring, but in view of the amount of further work required no development has yet been reported. Although the laboratory investigations have now come to an end contact is being continued with the Building Research Association who are maintaining their interest in latex-cement flooring.

G. MARTIN

Superintendent of Rubber Investigations

P. J. BURGESS

Chairman

Imperial Institute,

April, 1940

ANNUAL REPORT
LONDON ADVISORY COMMITTEE

INDEX

	Page
Abrasion resistance of rubber, testing technique	274
British Rubber Producers' Research Association: co-operation ...	257
Committee, meetings and personnel	257
Co-operation with other organisations	258
Finance	258
Films, dried latex, properties	270
Impurities in rubber	259, 274
Latex, testing	261
" Stability	268
" Effects of storage	270
" Films (dried), properties	270
" applied to road surfacing	276
Patents	263
Rubber globule, investigations	266
Road-surfacing mixtures	276
Specification of methods of testing standard rubber	273
Staff	257
Standardisation of raw rubber	259, 273
Stability of latex	268
Storage of latex	270
Testing of latex	260
Testing of dry rubber	272, 273
War, arrangements following outbreak	259

Publications

Publications of the Rubber Research Institute are issued in the following forms at prices stated at time of publication :

- (a) **Planting Manuals**—being articles of an instructional nature primarily for use on estates. These appear at irregular intervals.
- (b) **Bulletins**—being articles of special scientific interest printed and bound separately, appearing occasionally
- (c) **Journal**—being articles by officers of the Institute on current work, appearing at irregular intervals as information accumulates during the year
- (d) **Annual Reports** of the work of each Division during each year, with a summary by the Director R.R.I.
- (e) **Information Cards**—being concise precis of the processes of estate factory practice.
- (f) **Circulars**—being practical advice and instructions on specific topics of general current interest
- (g) **R.R.I. Planters' Bulletin**—being articles and notes in non-technical language on matters of current interest to rubber planters, appearing every few weeks.

The following publications have been issued and copies can be obtained on application at the prices given against each :—

(a) PLANTING MANUALS

- No. 1 "Guide to the Preparation of Plantation Rubber"
by B. J. Eaton (published August 1928) ... \$2.00
- No. 2 "Budding of Hevea in Modern Plantation Practice"
by F. Summers (published September 1928) (out of print)
- No. 3 "Plantation Sheet Rubber Manufacture"
by R. O. Bishop (published February 1932) ... \$2.00
- No. 4 "Latex Preservation and Shipment"
by R. O. Bishop and R. G. Fullerton
(published July 1932) ... \$2.00
- No. 5 "The History and Description of Clones of
Hevea Brasiliensis"
by C. E. T. Mann and C. C. T. Sharp
(published August 1933) (out of print)
Binder cover for filing the leaflets ... \$0.50
- No. 6 "The Uses and Control of Natural Undergrowth
on Rubber Estates"
by W. B. Haines (published July 1934) (out of print)
Binder cover for filing the Manual ... \$0.50
- No. 7 "Rubber-Growing—Elementary Principles and Practice"
(published February 1938) ... \$0.50
- No. 8 "Bud-grafting—Practical instructions in English,
Malay, Chinese and Tamil" (published August 1939) ... \$0.50

(b) BULLETINS

- No. 1 "Natural Coagulation of Hevea Latex"
by A. S. Corbet (published September 1929) (out of print)
- No. 2 "A Study of the Effect of Damp Storage on
Raw Rubber"
by B. J. Eaton and R. G. Fullerton
(published October 1929) ... \$1.00
- No. 3 "The Root Disease Problem on Old Rubber
Areas in Malaya"
by A. Sharples and A. R. Sanderson
(published November 1931) ... \$1.00
- No. 4 "A Summary of Meteorological Records, Soils Division"
by W. B. Haines (published December 1931) ... \$1.00
- No. 5 "Variations in the Composition of Latex from
Clone and Seedling Rubber"
by J. L. Wiltshire (published July 1934) ... \$1.00

(c) JOURNAL OF THE R.R.I.

Vol. 1	Nos. 1, 2—two numbers combined (published 1929)	...	\$1.00
Vol. 1	" 3, 4 (published 1929)		
Vol. 2	" 1, 2, 3, 4 (" 1930)		
Vol. 3	" 1, 2, 3 (" 1931/32)		
Vol. 4	" 1, 2 (" 1932)		
Vol. 5	" 1, 2, 3, 4 (" 1933/34)		
Vol. 6	" 1, 2 (" 1935)		
Vol. 7	" 1, 2 (" 1936/37)		
Vol. 8	" 1, 2, 3 (" 1937/38)		
Vol. 9	No. 1 (" 1939)		
Vol. 9	Communications Nos. 236 to 244 (published 1939)	each number ...	\$0.10

(d) ANNUAL REPORTS

From 1928	each ...	\$1.00
-----------	----------	--------

(e) INFORMATION CARDS

dealing with various phases of Rubber Estate Factory Practice and Defects in Raw Rubber 1c—7c (published February 1934)	in Malaya ...	\$0.50
	outside Malaya ...	\$1.00

(f) CIRCULARS

See page 22 of Annual Report 1939	...	free
-----------------------------------	-----	------

(g) R.R.I. PLANTERS' BULLETIN

Nos. 1 to 8 (published 1939)	each ...	\$0.05
------------------------------	----------	--------

Bank Commission should be added to outstation cheques

THE RUBBER RESEARCH INSTITUTE OF MALAYA

STAFF

at the 31st December 1939

Administration

Director	...	...	H. J. PAGE, M.B.E., B.Sc.(Lond.), F.I.C., F.I.R.I.
Assistant to the Director	...	...	A. MOORE, B.Sc. (Lond.), A.R.C.S.,— <i>on leave</i>
Statistician	...	...	H. FAIRFIELD SMITH, B.Sc. (Agr.) (Edin.), M.S.A. (Cornell)
Small - holders' Officer	...	...	Advisory R. H. MEIKLE, B.Sc. (Edin.)

Botanical Division

Head of Division	...	...	C. E. T. MANN, M.Sc. (Lond.), F.I.R.I.,— <i>on leave</i>
Botanist	(Acting Head of Division)	...	C. C. T. SHARP
Botanist	...	...	E. R. GUEST, B.Sc. (Lond.), A.R.C.S., A.I.C.T.A.
Botanist	...	...	E. D. C. BAPTIST, Ph.D. (Lond.), M.Sc., A.R.C.S., D.I.C.,
Botanist	...	...	N. WRIGHT, B.Sc. (Lond.), A.R.C.S., A.I.C.T.A.
Asst. Botanist	...	...	K. N. KAIMAL, B.A. (Madras)
Asst. Botanist	...	...	T. V. VAIDYANATHAN, B. Agric. (Bombay)

Chemical Division

Head of Division	...	...	W. S. DAVEY, B.Sc. (Lond.), F.I.C., F.I.R.I.
Chemist	...	...	J. D. HASTINGS, B.Sc. (Lond.)
Chemical Engineer	...	...	J. H. PIDDLESDEN, M.Sc. (Lond.), A.R.C.S., D.I.C., A.M.I.Chem.E.,— <i>on leave</i>
Chemist	...	...	V. H. WENTWORTH, B.Sc.(Lond.), A.I.C., A.I.R.I.(Sc.), A.R.Ae.S.I.
Chemist	...	...	<i>Vacant.</i>
Asst. Chemist	...	...	K. C. SEKAR, B.A. (Madras)

Pathological Division

Head of Division	...	...	F. BEELEY, B.Sc. (Leeds)
Pathologist	...	...	R. P. N. NAPPER, M.A., Dip. Agr. (Cantab.)
Entomologist	...	...	L. D. E. F. VESSEY FITZGERALD, B.Sc. (Agric.) (Lond.) Dip. Agri. (Wye), A.I.C.T.A.
Asst. Pathologist	...	...	K. P. JOHN, B.A., (Madras)

Soils Division

Head of Division	...	...	C. G. AKHURST, B.Sc. (Lond.), A.R.C.S., A.I.C.T.A.
Soils Chemist	...	...	G. OWEN, M.Sc. (Wales)
Soils Chemist	...	...	A. W. J. DYCK, Ph.D. (McGill), M.A. (Sask.)
Asst. Soils Chemist	...	...	K. S. PILLAY, B.A. (Madras), F.C.S.

Experiment Station

Manager	...	...	T. N. DICKSON, A.I.S.P.
Assistant Manager	...	...	R. F. HARLEY, A.I.S.P.
Assistant	...	...	J. H. TOVEY

Secretary

H. S. BLACKLIN

LONDON ADVISORY COMMITTEE FOR RUBBER RESEARCH (CEYLON & MALAYA)

at the 31st December 1939

Mr. P. J. BURGESS, M.A., F.C.S., (Chairman)	}	Nominees of the Rubber Growers' Association
Mr. ERIC MACFADYEN		
Mr. J. L. MILNE		
Mr. G. H. MASEFIELD		
Mr. GEORGE BROWN		
SIR HERBERT WRIGHT		
Lt. Col. J. SEALY CLARKE		Nominee of the Research Association of British Rubber Manufacturers
Sir FRANK STOCKDALE, K.C.M.G., C.B.E.		Nominee of the Colonial Advisory Council of Agriculture and Animal Health
Mr. J. LORNE, C.M.G., M.A., B.Sc.		Nominee of the Malayan Governments
Dr. W. YOUNGMAN, D.Sc., Ph.D.		Nominee of the Ceylon Government
virtute officii {	The Director, Imperial Institute	} Sir HARRY LINDSAY, K.C.I.E., C.B.E.
	The Director, Botanical Laboratories, Imperial College of Science and Technology	
	The Director, Imperial Mycological Institute, Kew	} Mr. S. F. ASHBY, B.Sc.
	The Director, Rothamsted Experimental Station	
Dr. H. A. TEMPANY, C.B.E., D.Sc., F.I.C.		Co-opted.
Secretary: Mr. J. A. NELSON, B.Sc.		Imperial Institute, London, S.W. 7

TECHNICAL SUB-COMMITTEE

All the members of the London Advisory Committee with the addition of the following co-opted members:—

Mr. B. D. PORRITT, M.Sc., F.I.C., FR.S.E., F.I.R.I.
 Mr. H. N. RIDLEY, C.M.G., M.A., F.R.S.
 Mr. W. C. SMITH, F.C.S., F.I.R.I.
 Dr. D. F. TWISS, D.Sc., F.I.C., F.I.R.I.
 Dr. H. P. STEVENS, M.A., Ph.D., F.I.C.
 Prof. R. G. H. CLEMENTS, M.C., M.Inst.C.E.
 Mr. G. E. COOMBS, B.Sc.
 Mr. G. G. BALAZS

STAFF

Superintendent of Laboratories	...	G. MARTIN, B.Sc., A.I.C., F.I.R.I.
Chemist	...	H. C. BAKER, M.Sc. (Lond.), A.I.C., A.I.R.I. (Sc.)
Chemist	...	W. G. WREN, B.Sc., A.R.C.S.
Technical Assistant	...	L. L. STEWART
Technical Assistant	...	F. J. COKER, L.I.R.I., (Tech.)
Technical Assistant	...	G. PANNELL

Edited by H. J. Page on behalf of the Board of the
Rubber Research Institute of Malaya.